Norwegian
Meteorological Institute
met.no

27 year simulations using ROMS and MIPOM: Validation and Comparison

Jon Albretsen and *Lars Petter Røed*[1]

[1]Also affiliated with Department of Geosciences, University of Oslo, Norway

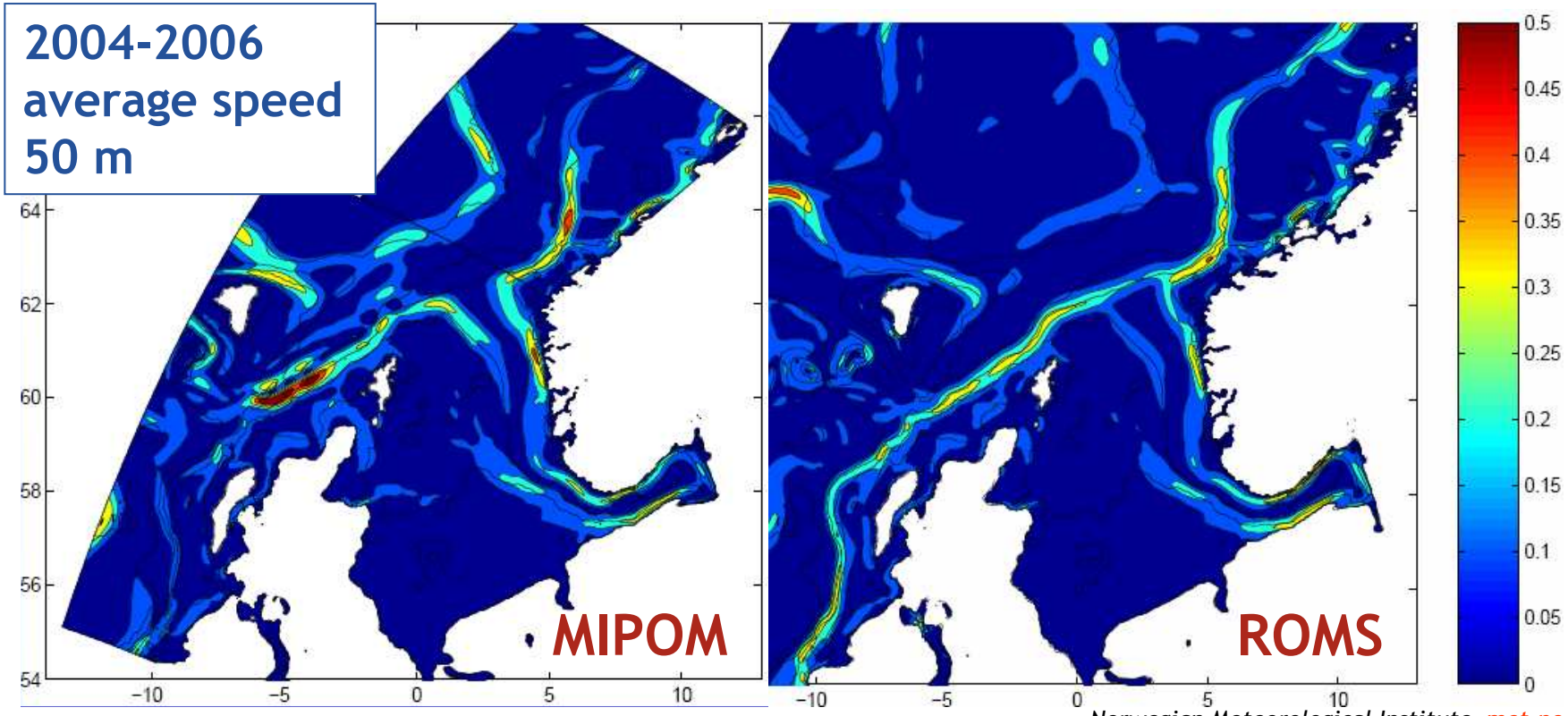
Outline

- Background and motivation
- Models and observations
- Results
- Conclusions

Background and Motivation

- ROMS to replace MIPOM
- Earlier results (CONMAN) indicates that ROMS is superior to MIPOM

LaCasce et al. (2007)

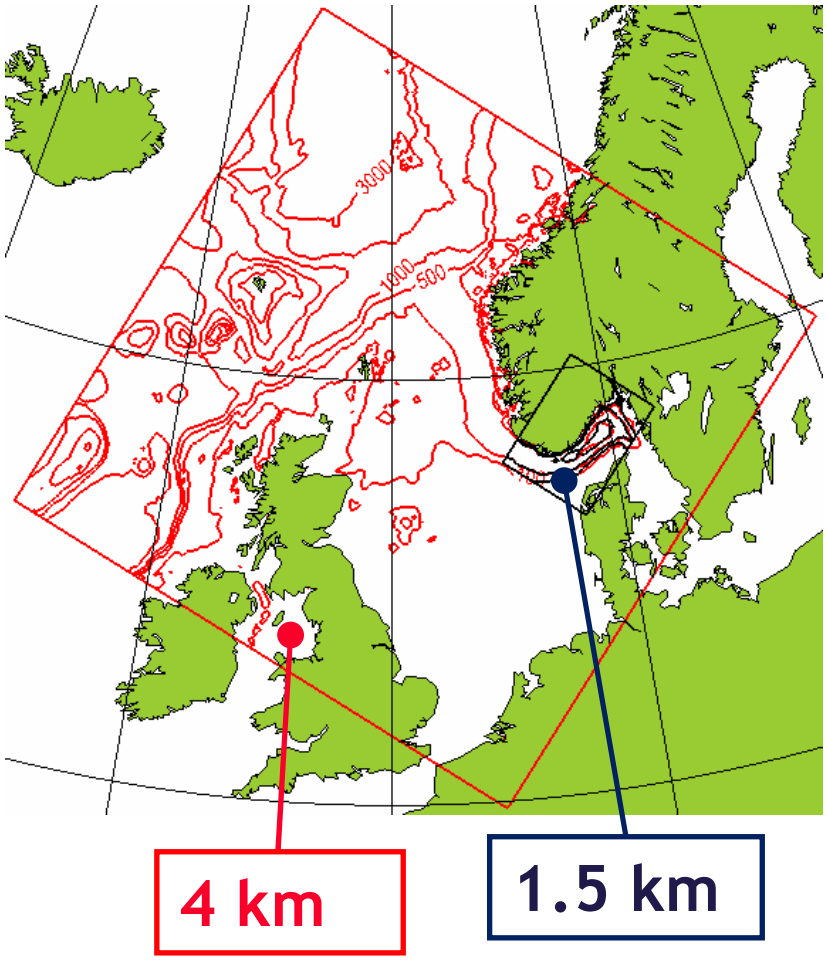


Background and Motivation

- MIPOM
  - old code,
  - yesterdays numerics
  - in operation since early 1990s
- ROMS
  - Modern code
  - More sophisticated numerics, e.g., better conservation properties
  - Developed for coastal shelf seas

Simulations

- *Four* hindcasts each 27 years long
- Motivation: To ensure that the model is well identified
- Area covered:
  - North Sea/Skagerrak
- Grids employed:
  - Eddy-permitting: 4km
  - Eddy-resolving: 1.5km



Simulations

- 27 year period:
  - 1981–2007 (+ 1980 spin-up)
- 4 simulations:
  - 2 x MIPOM : 4 km and 1.5 km
  - 2 x ROMS : 4 km and 1.5 km
- Atmospheric forcing:
  - ERA40 + ECMWF operational analysis 2002-2007
- Tidal forcing:
  - 8 major tidal components
  - Forced at open boundaries

Simulations

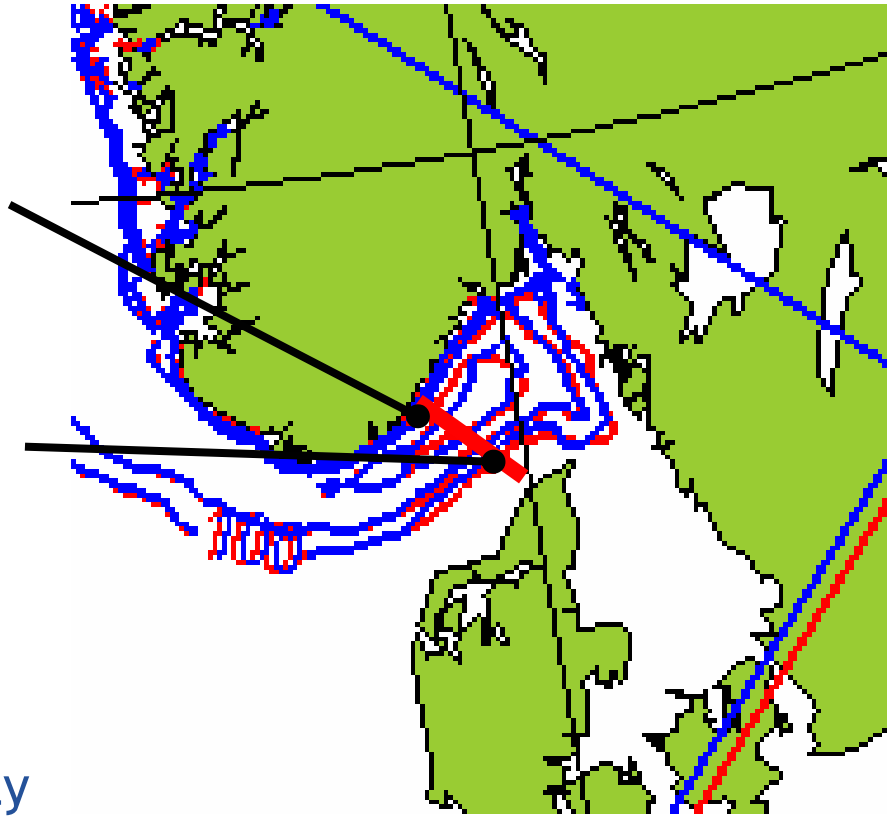
- Forcing at open boundaries:
  - 4 km: SODA reanalysis + 2005-2007 climatology
  - 1.5 km: Nested into 4 km
- Rivers:
  - Climatology
- Baltic outflow
  - S=12 psu
- No data-assimilation

Model facts

Item	MIPOM		ROMS	
Resolution	4 km	1.5 km	4 km	1.5 km
# of vertical levels	26	21	32	32
Long (internal) time step	150 s	60 s	120 s	90 s
Ratio of internal to external time step	30	40	30	30
Horizontal dissipation	Smagorinsky		No explicit diffusion	
Vertical mixing	Mellor-Yamada 2.5 level		GLS mixing scheme	
Horizontal advection scheme	2nd order centered		**3rd order upwind**	
Surface fluxes	**MI-IM**		**Standard ROMS bulk fluxes**	

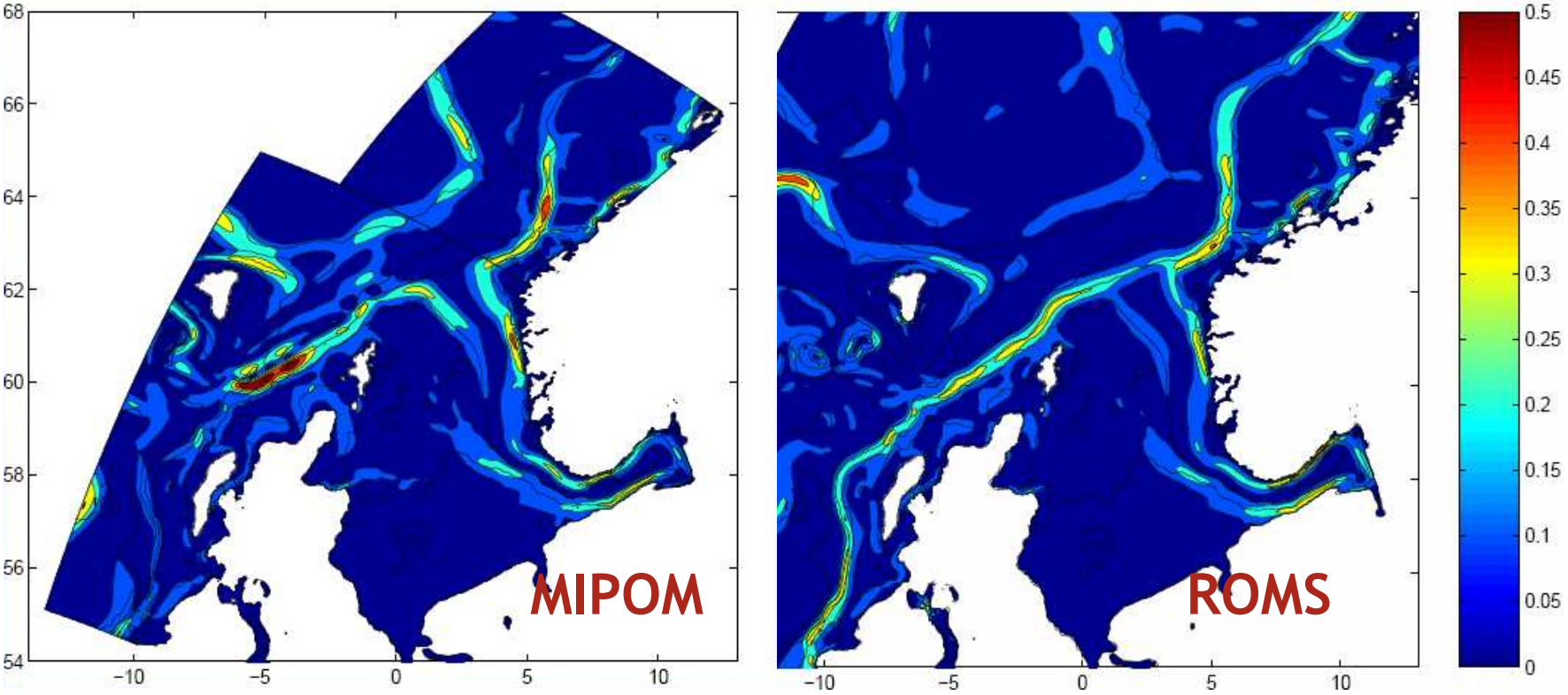
Observations for validation

- Institute of Marine Research:
  1. Current measurements (one location, 160 day period)
  2. Monthly data from the Hirtshals – Torungen section (12 stations, all years)
- ICES database
  - About 250.000 S and T measurements irregularly distributed in time and space



Comparison with earlier results

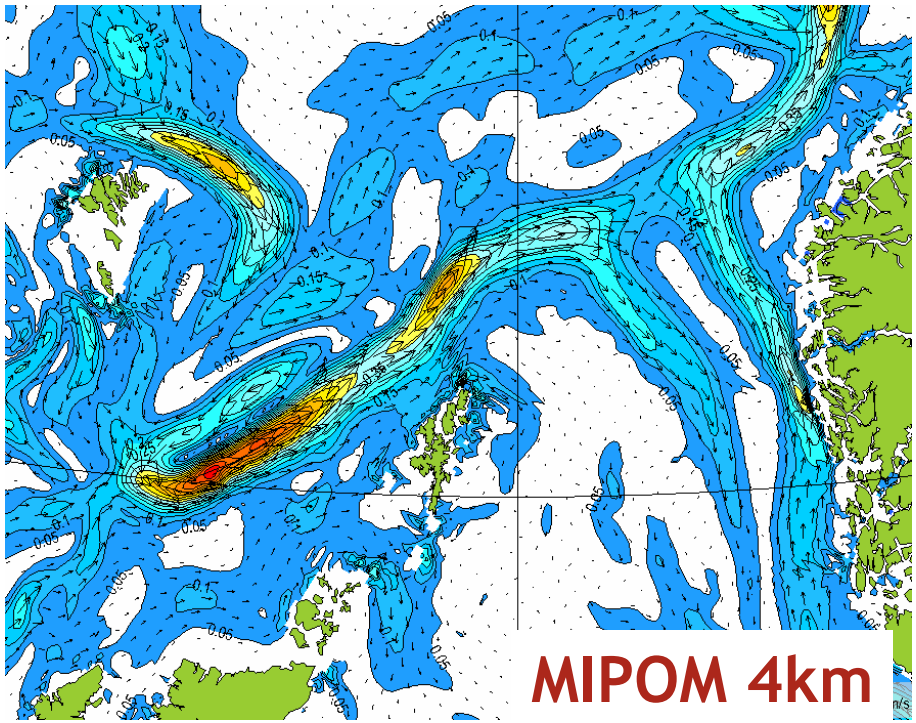
2004-2006 (3 yr) average speed at 50 m

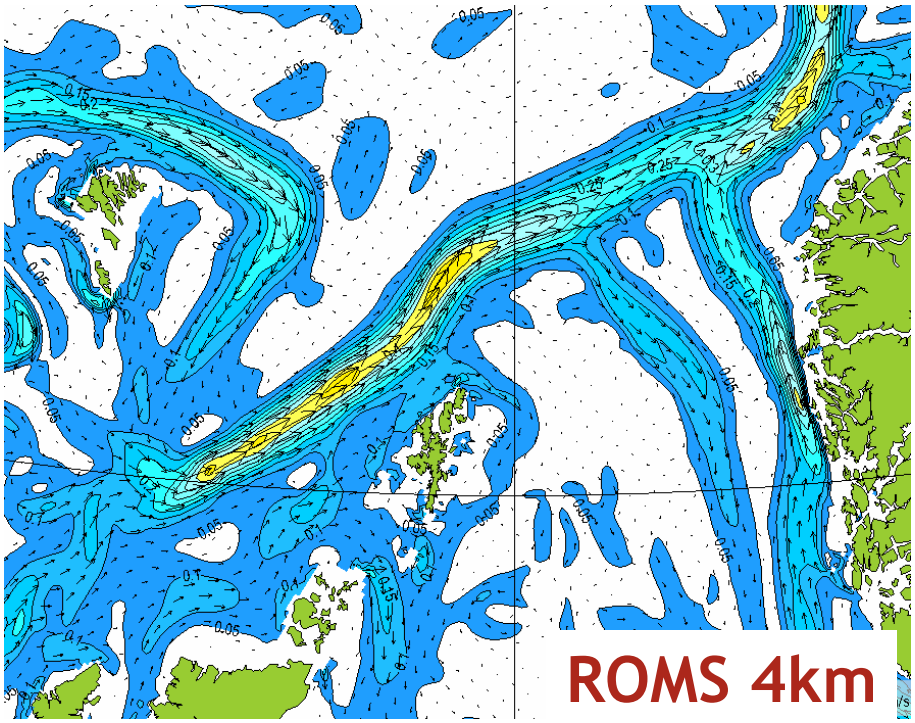


LaCasce et al. (2007): *"The ROMS velocities are more energetic and compare more favorably with in situ observations, as do the ROMS-derived means"*

Currents off western Norway

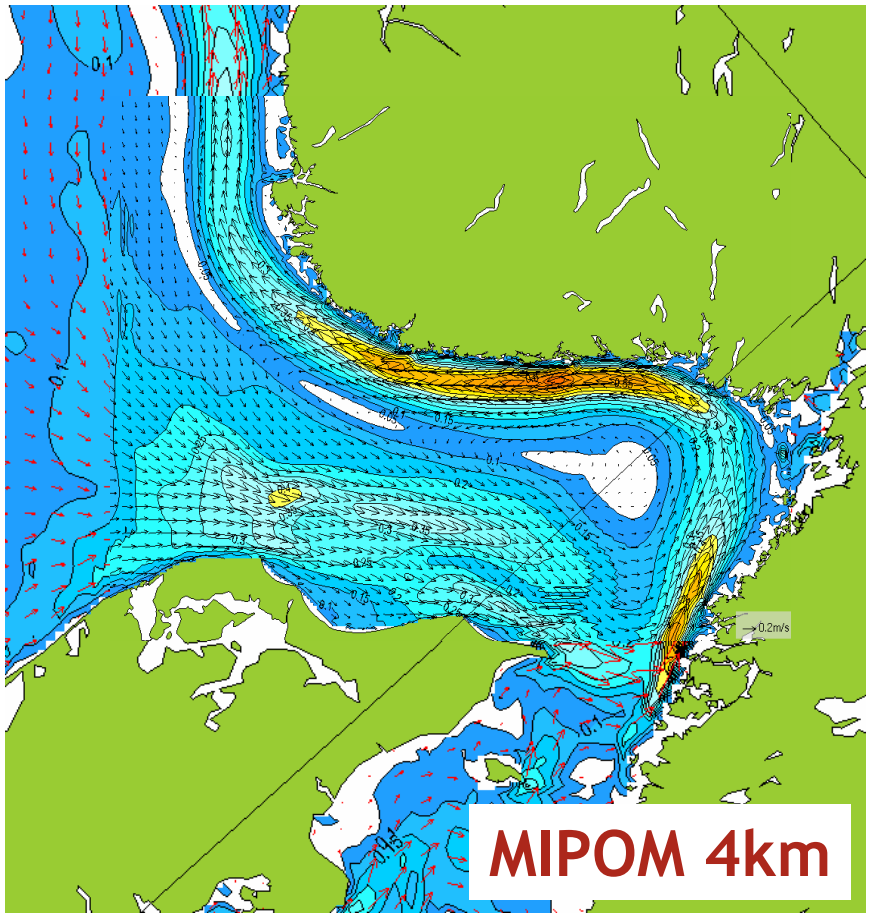
27 yr average speed at 50 m (m/s)

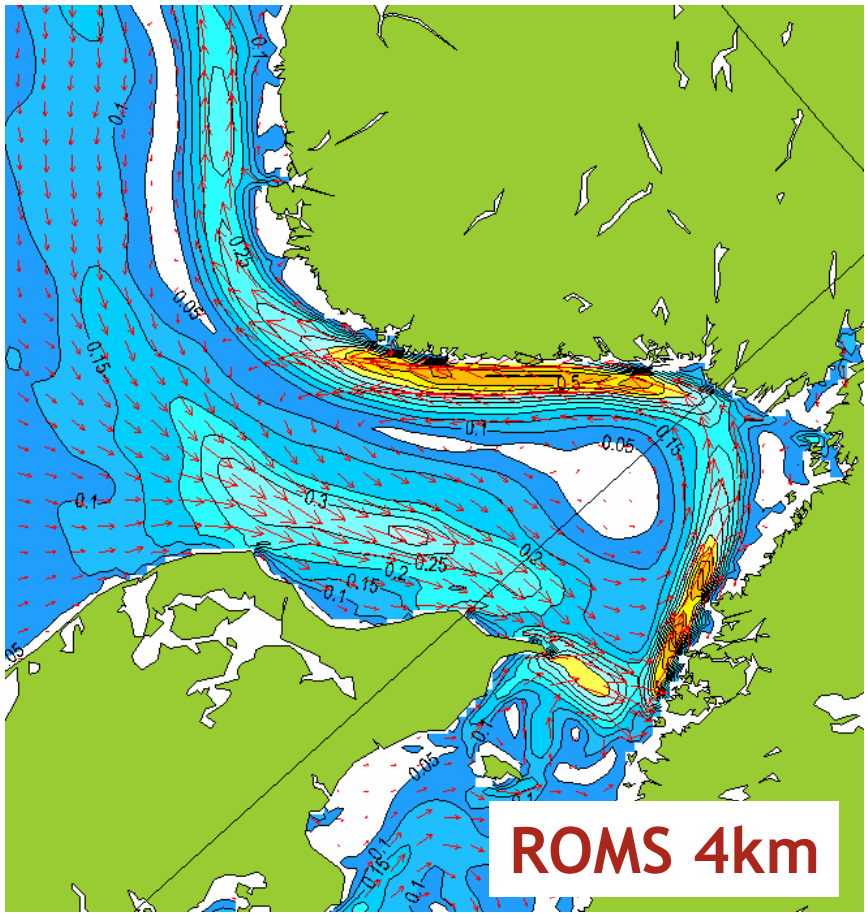




Surface currents Skagerrak

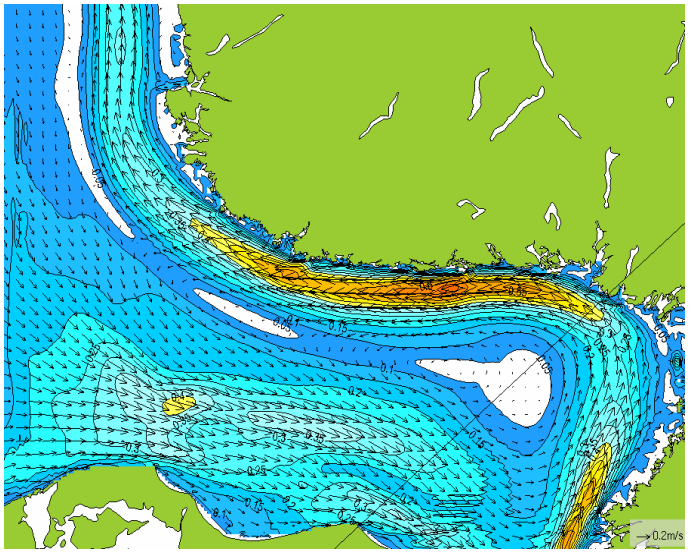
27 average (m/s)

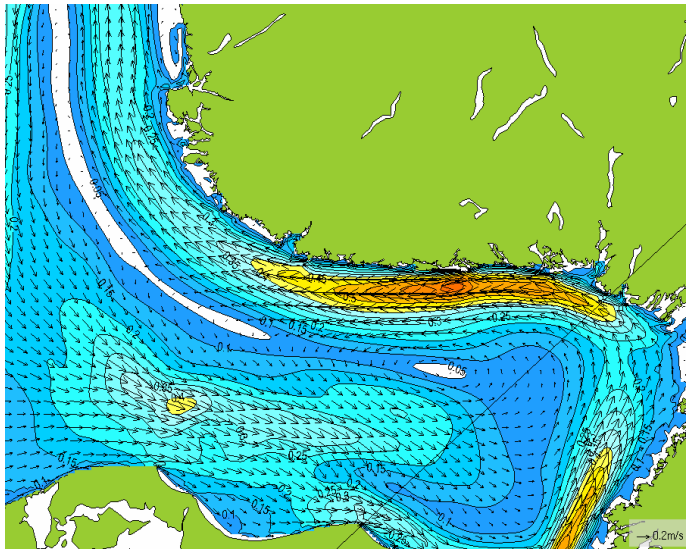




Surface currents Skagerrak

27 average (m/s)

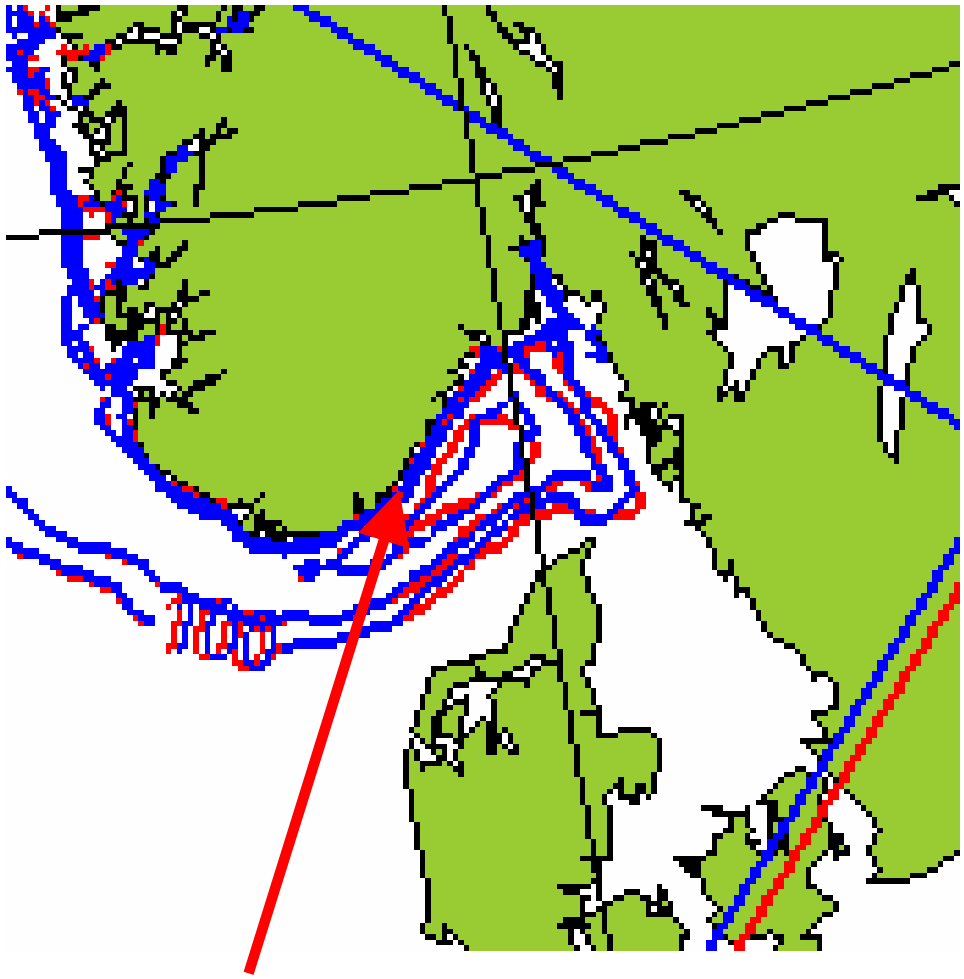




MIPOM 1.5km

ROMS 1.5km

Validation of currents

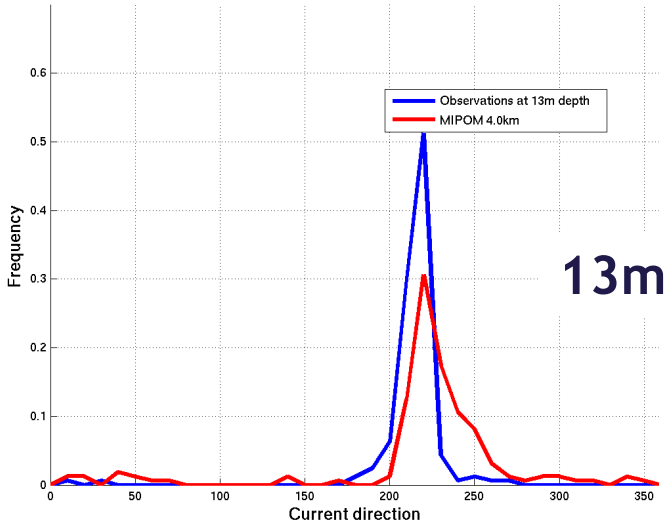


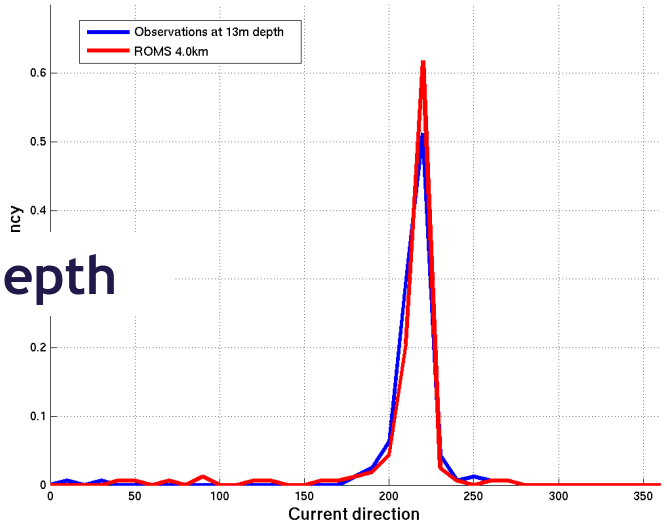
Location: 58.37N, 8.51E

Validation: Directional PDFs

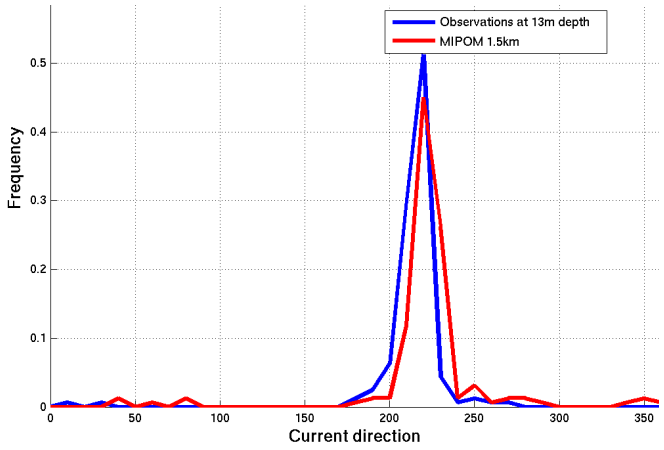
4km

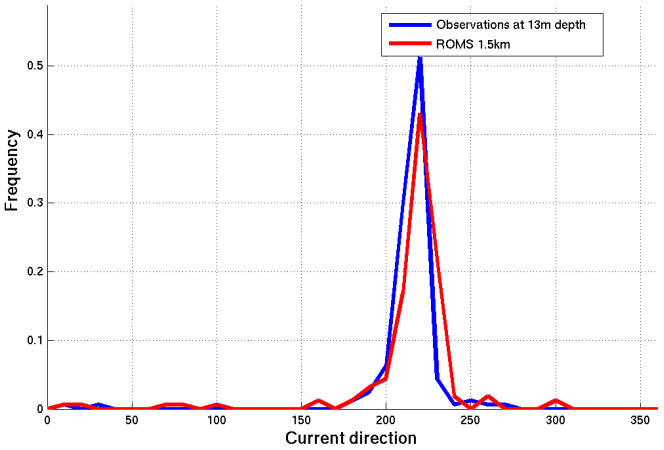
13m depth





1.5km





MIPOM

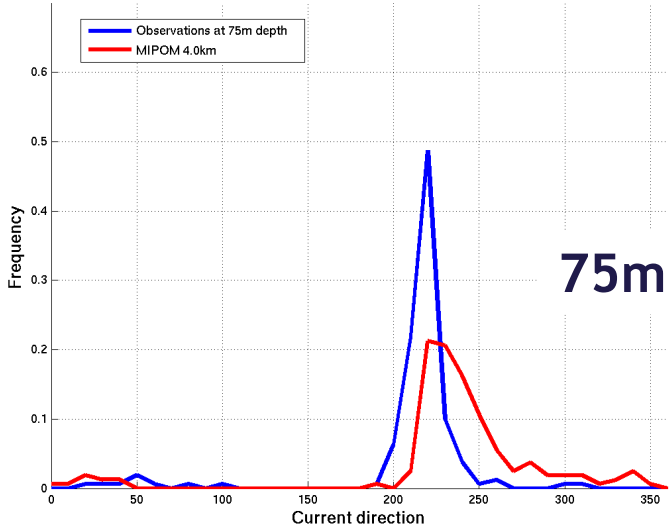
ROMS

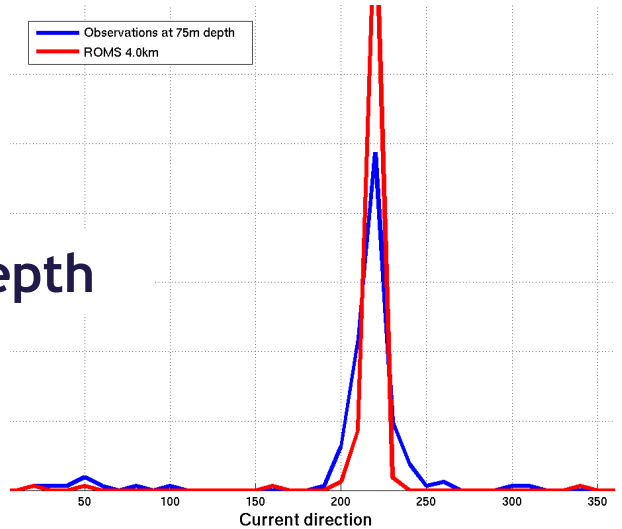
Validation: Directional PDFs

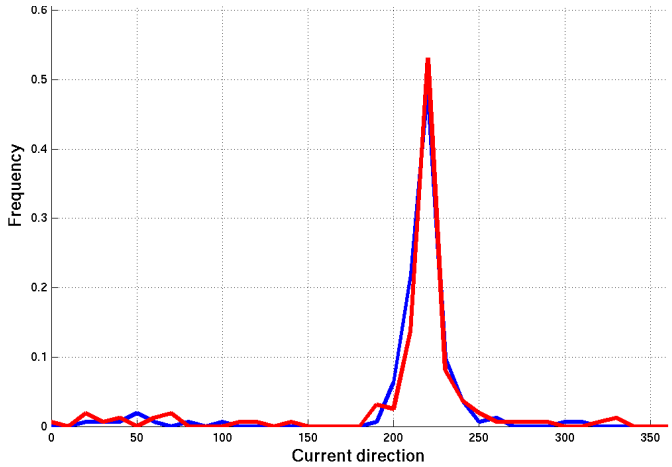
4km

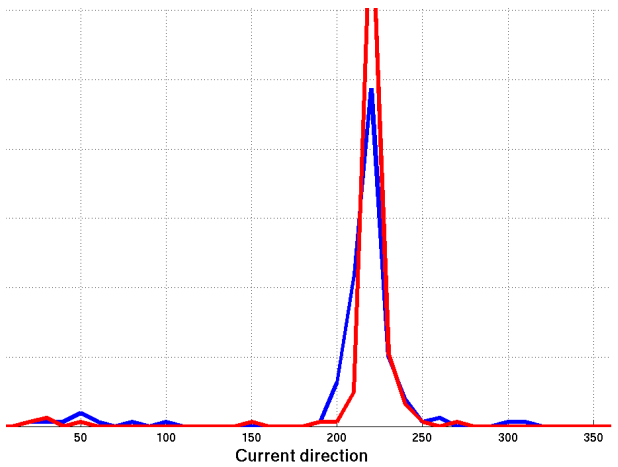
1.5km

75m depth









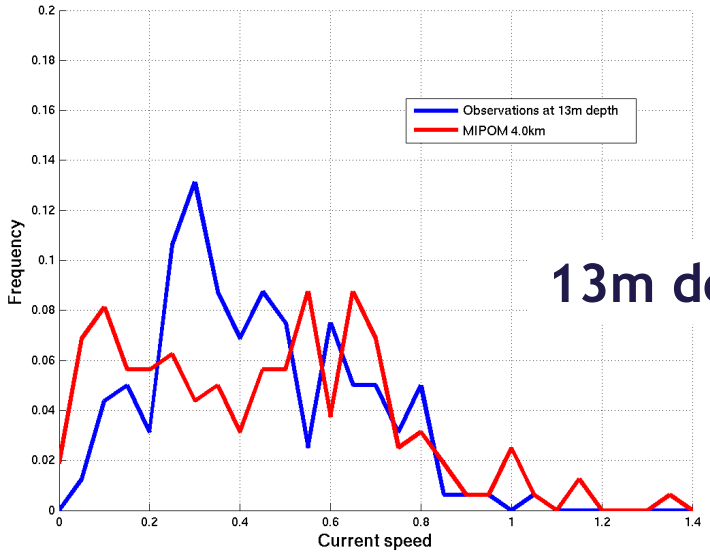
MIPOM

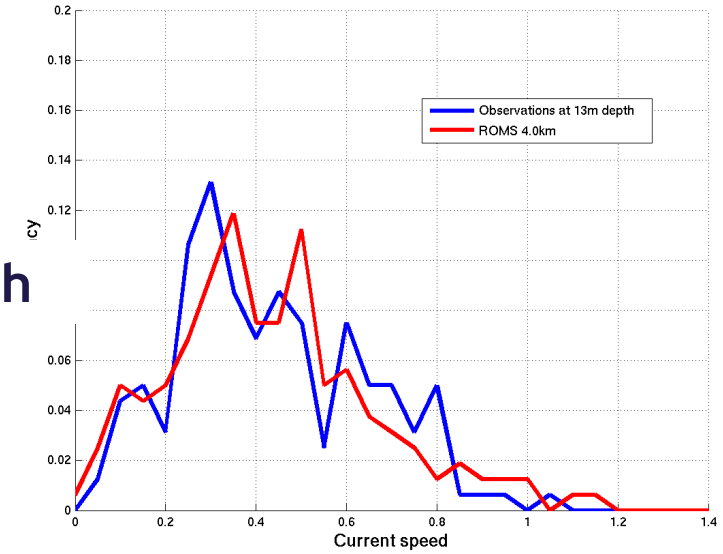
ROMS

Validation: Speed PDFs

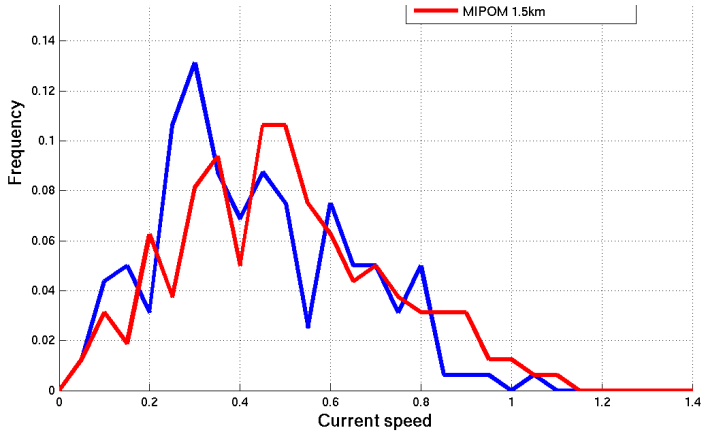
4km

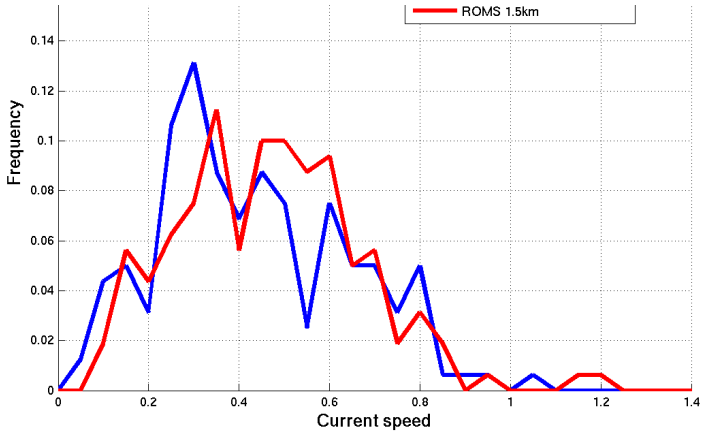
13m depth





1.5km





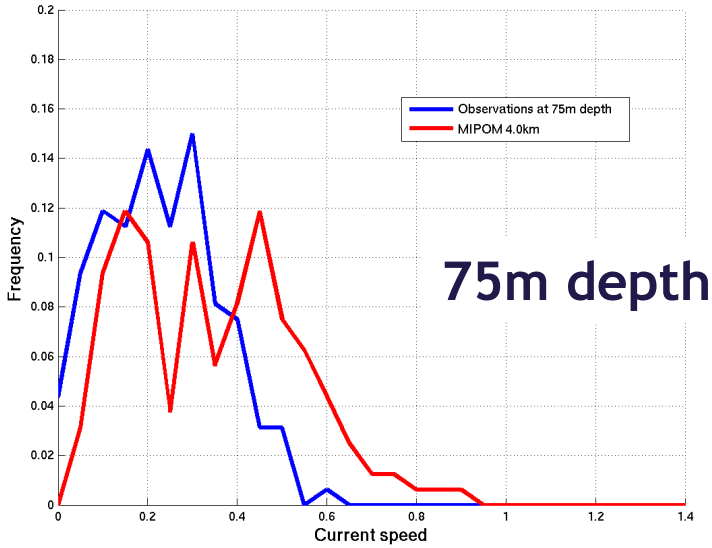
MIPOM

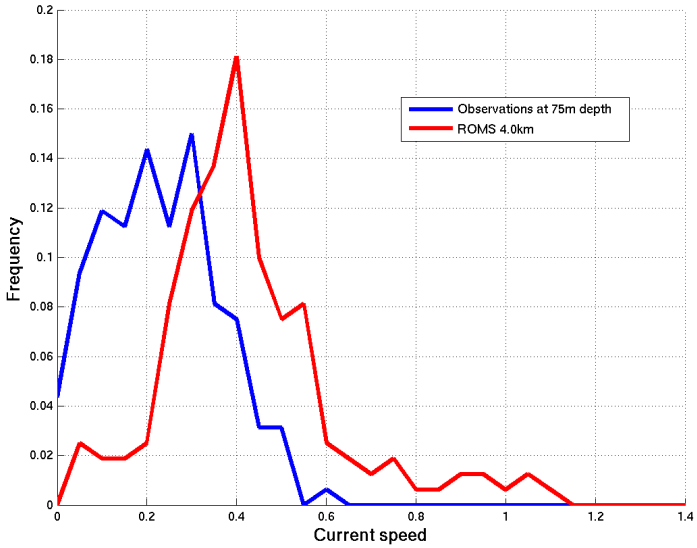
ROMS

Validation: Speed PDFs

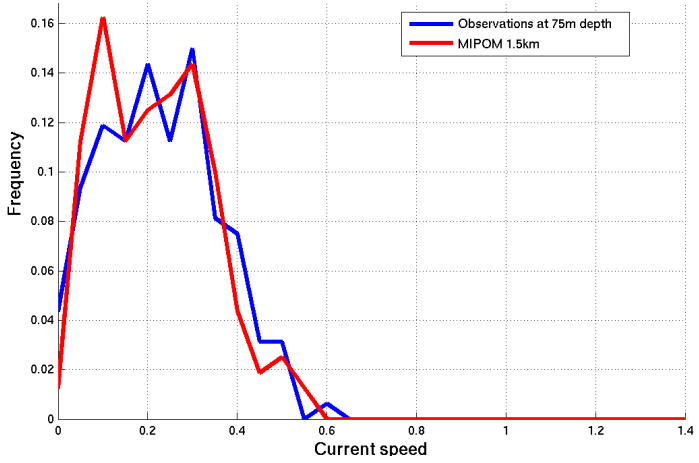
4km

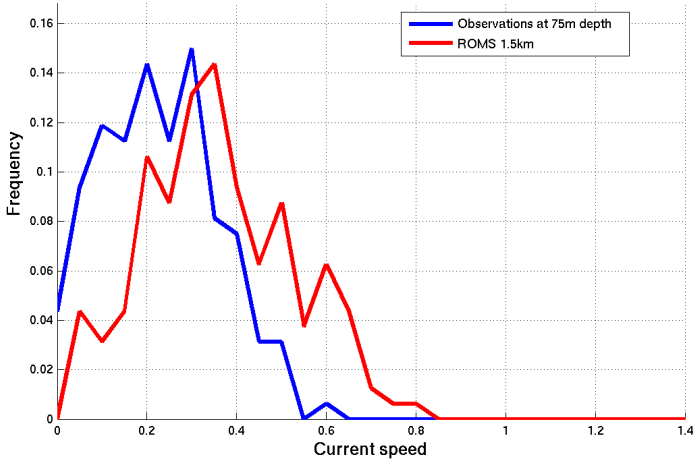
75m depth





1.5km



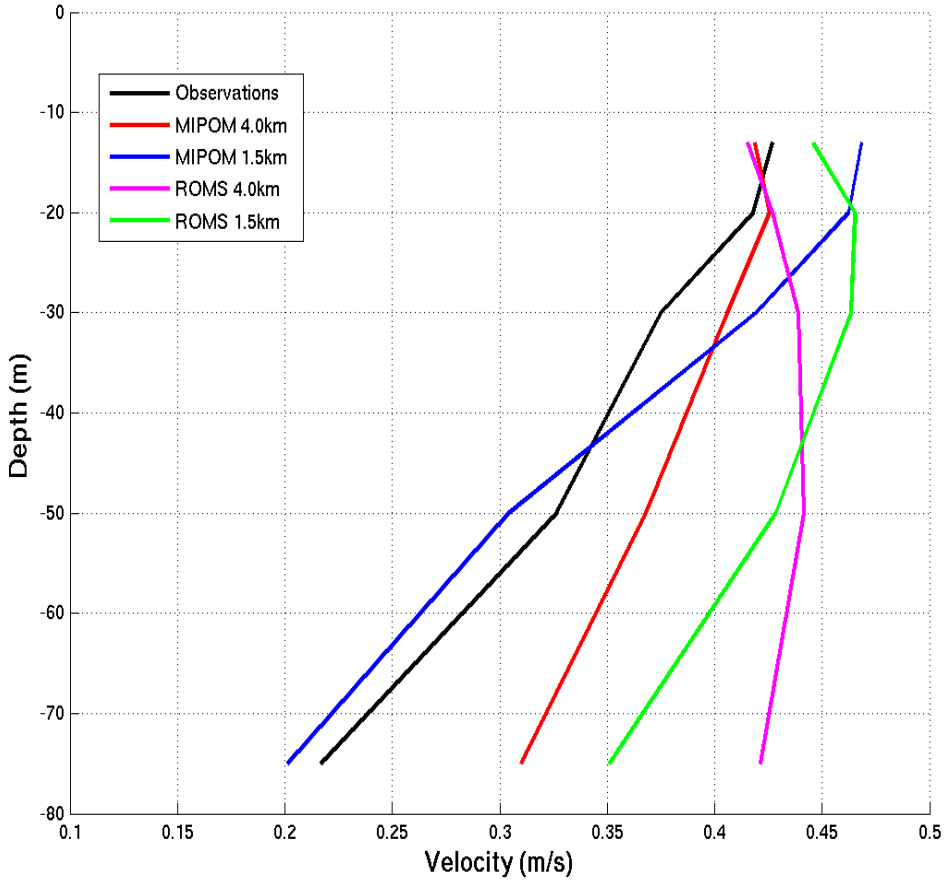


MIPOM

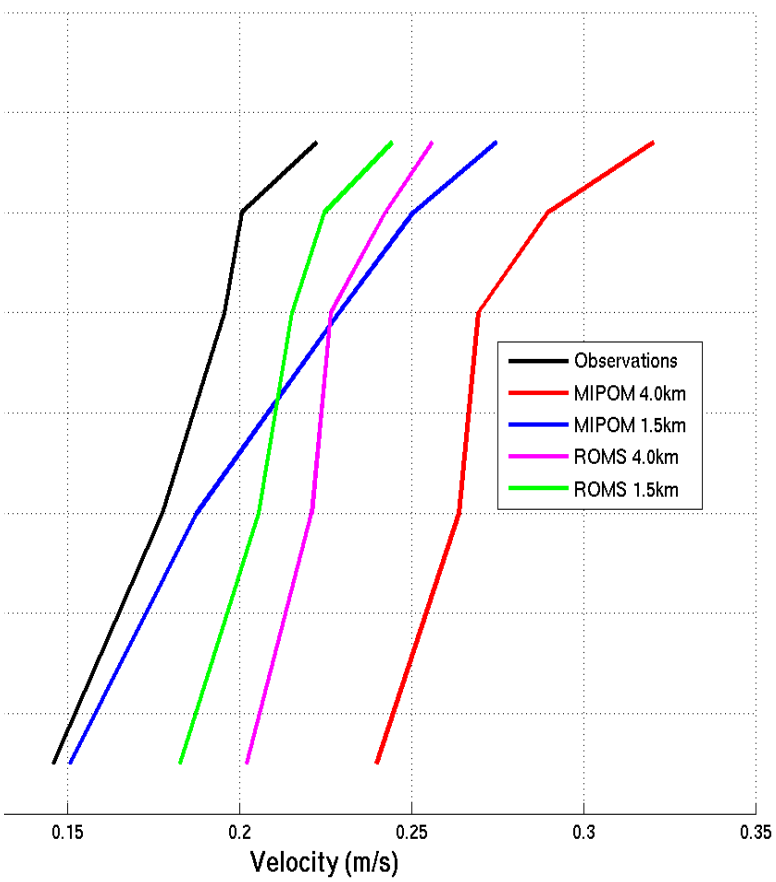
ROMS

Validation of currents

Mean

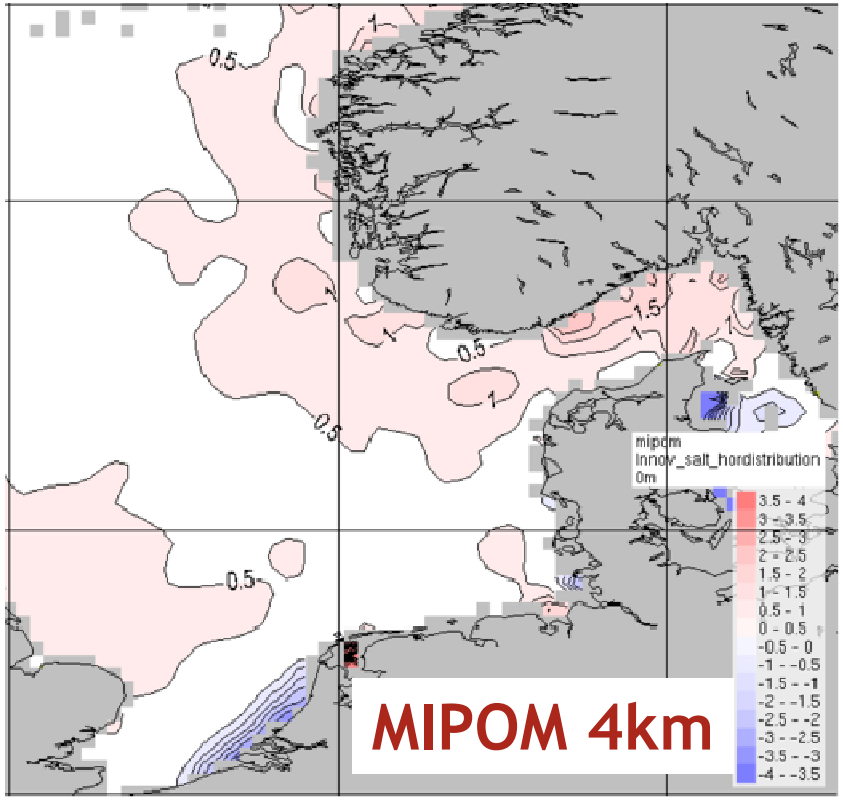


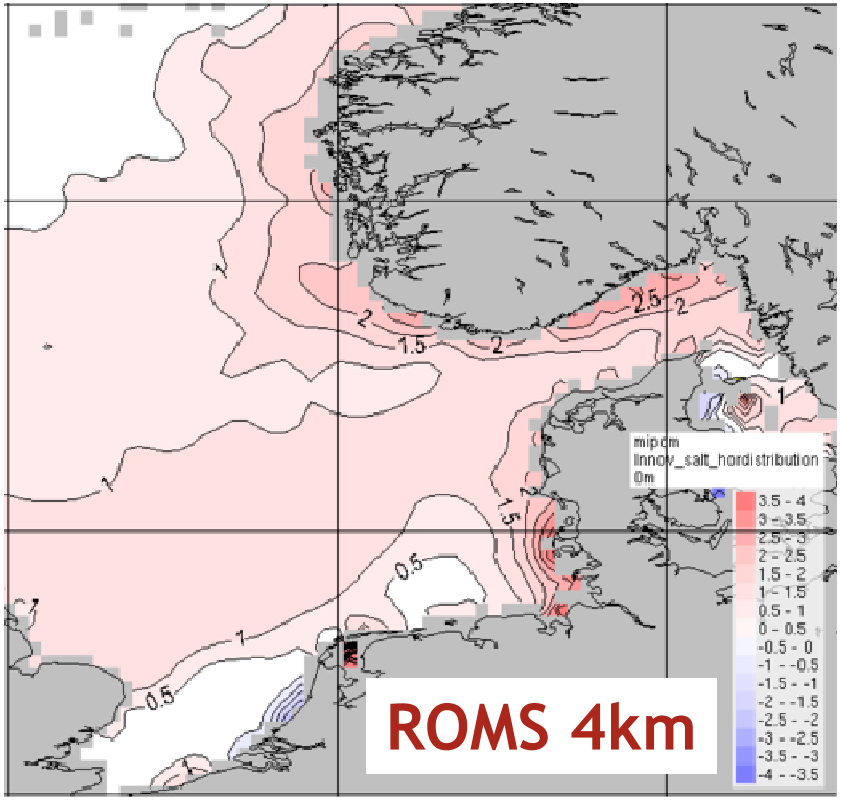
Standard deviation



Salinity bias (mod - ICES obs)

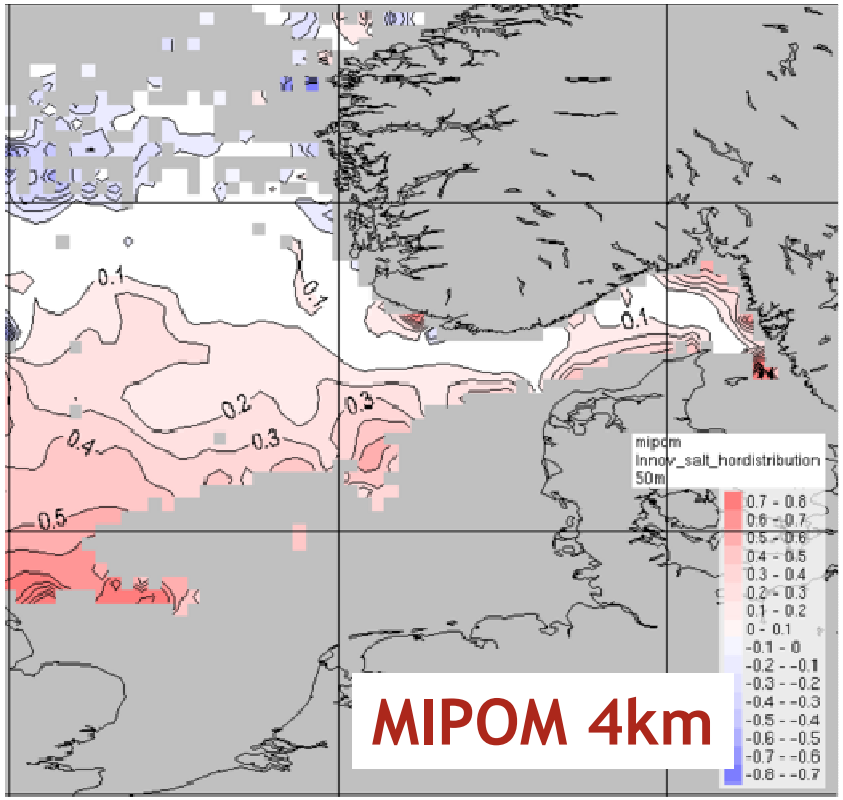
27 average; upper 20 m

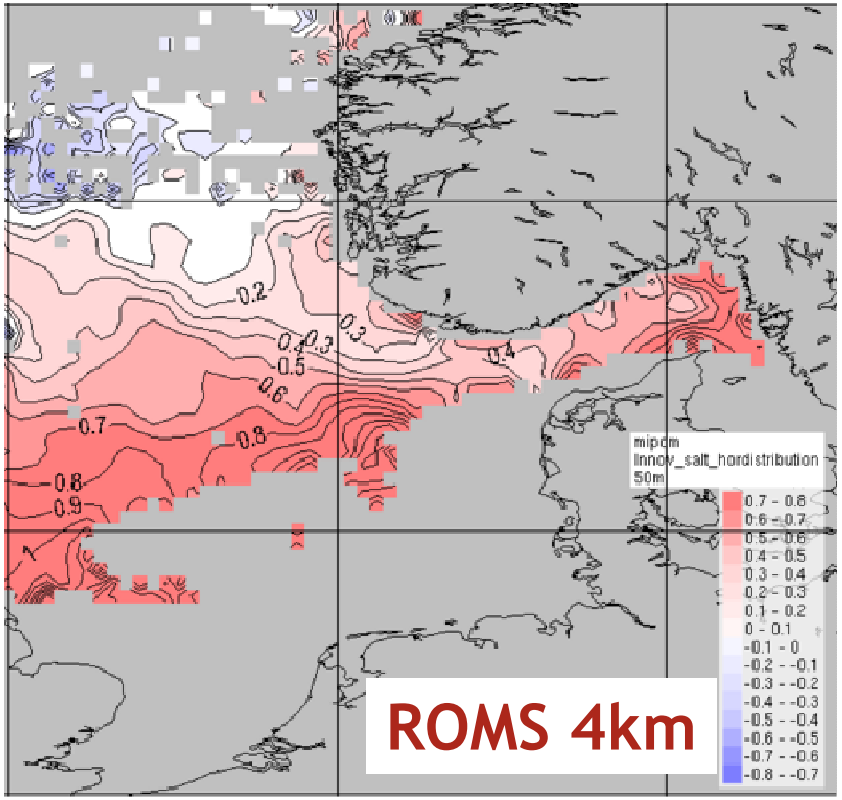




Salinity bias (mod - ICES obs)

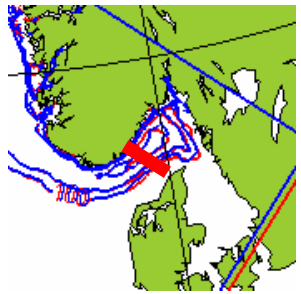
27 average; 50-600 m

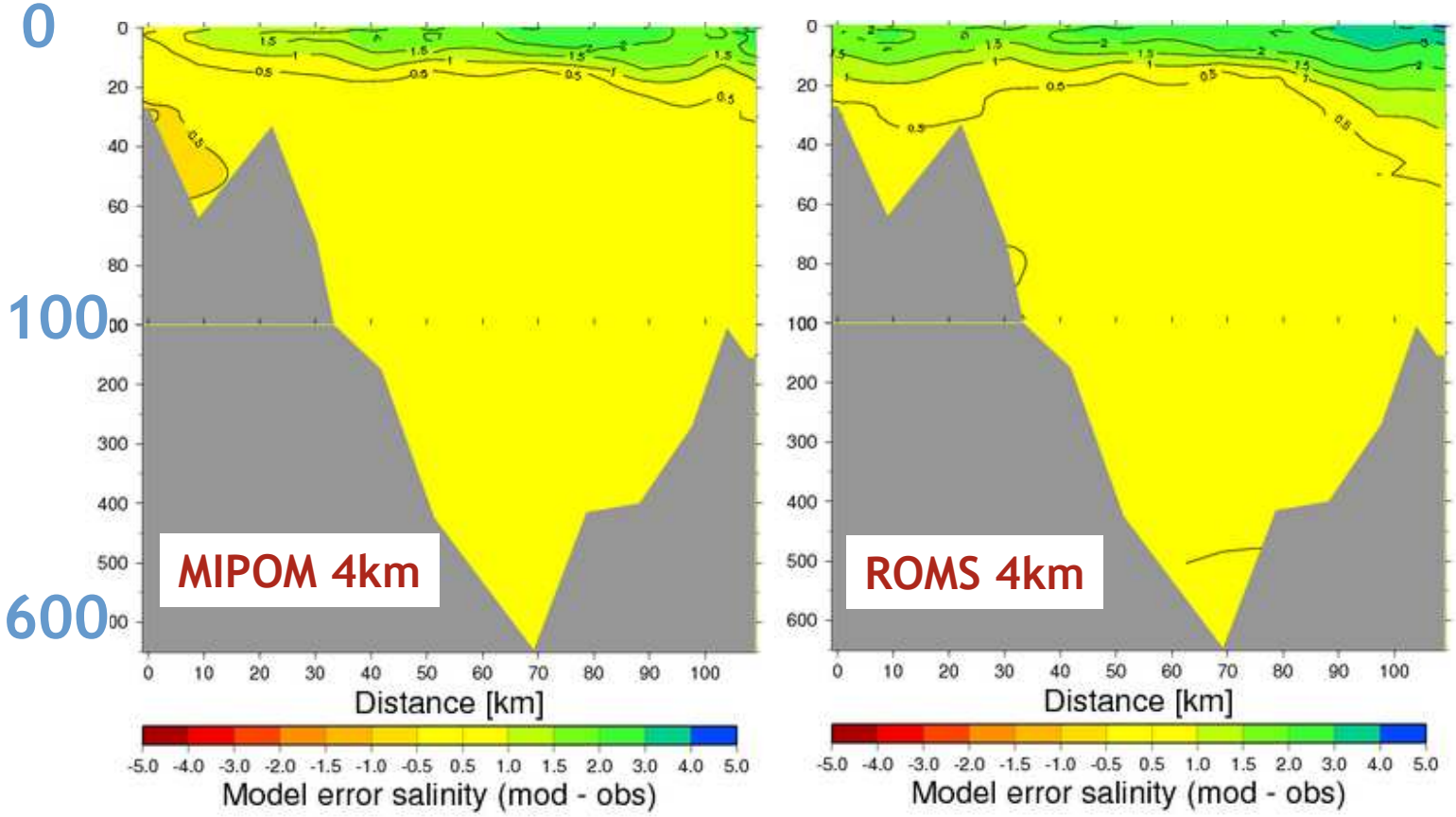




Salinity bias (mod - IMR obs)

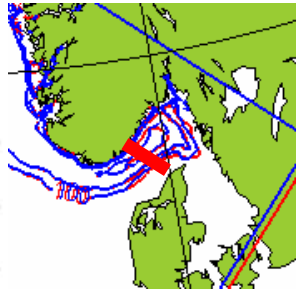
27 average

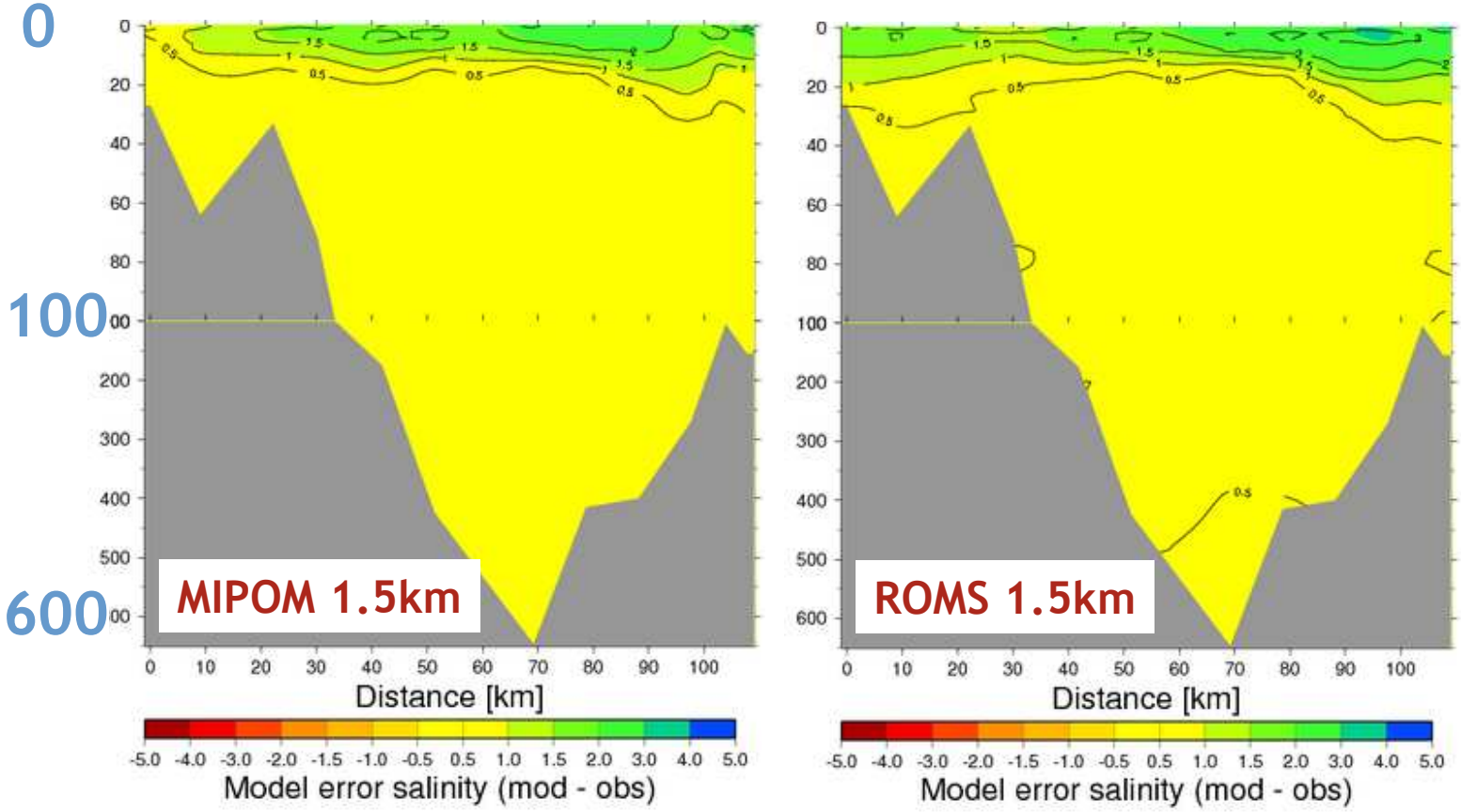




Salinity bias (mod - IMR obs)

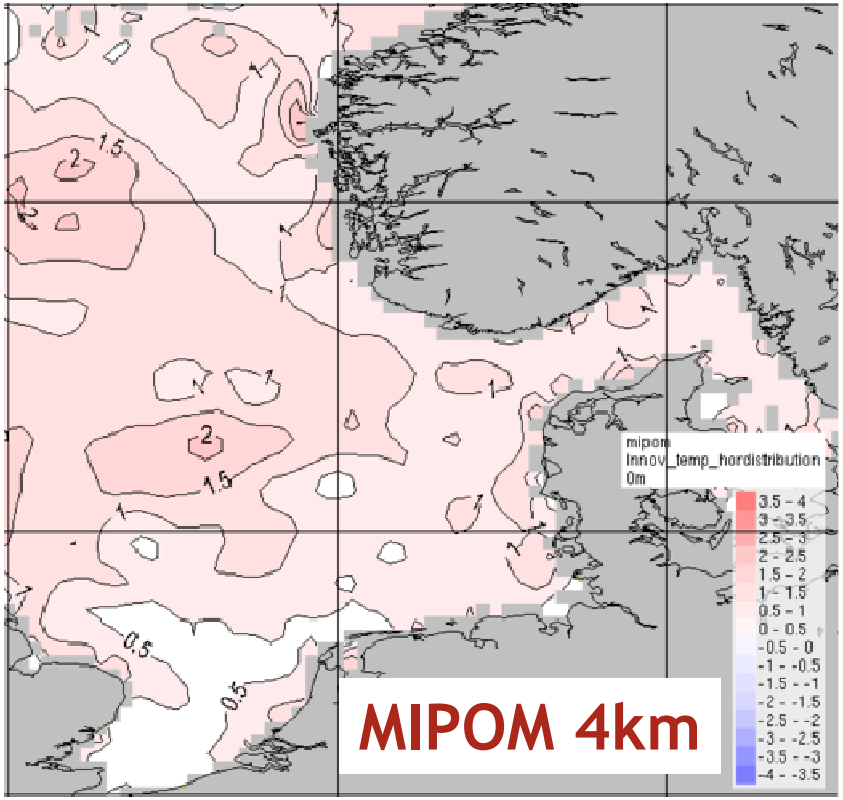
27 average

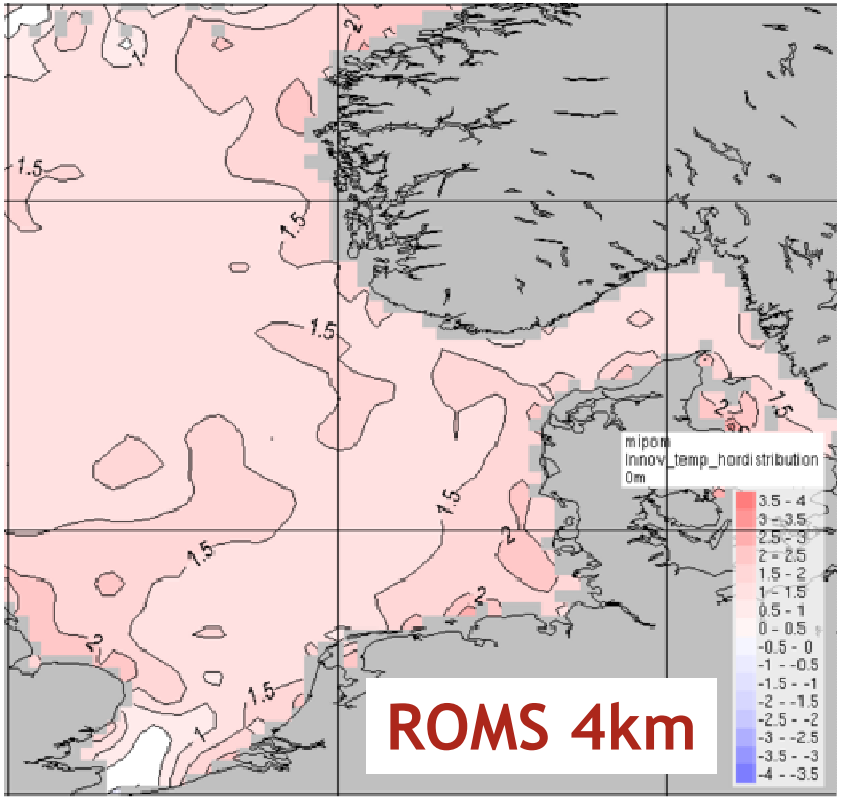




Temperature bias (mod – ICES obs)

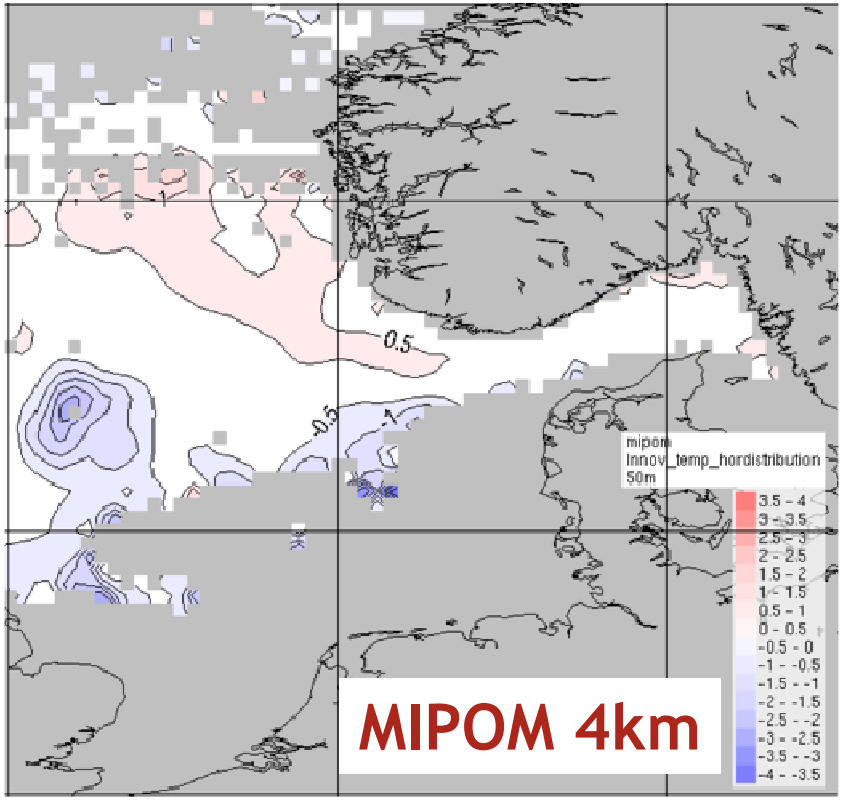
1981-2007 average; upper 20 m

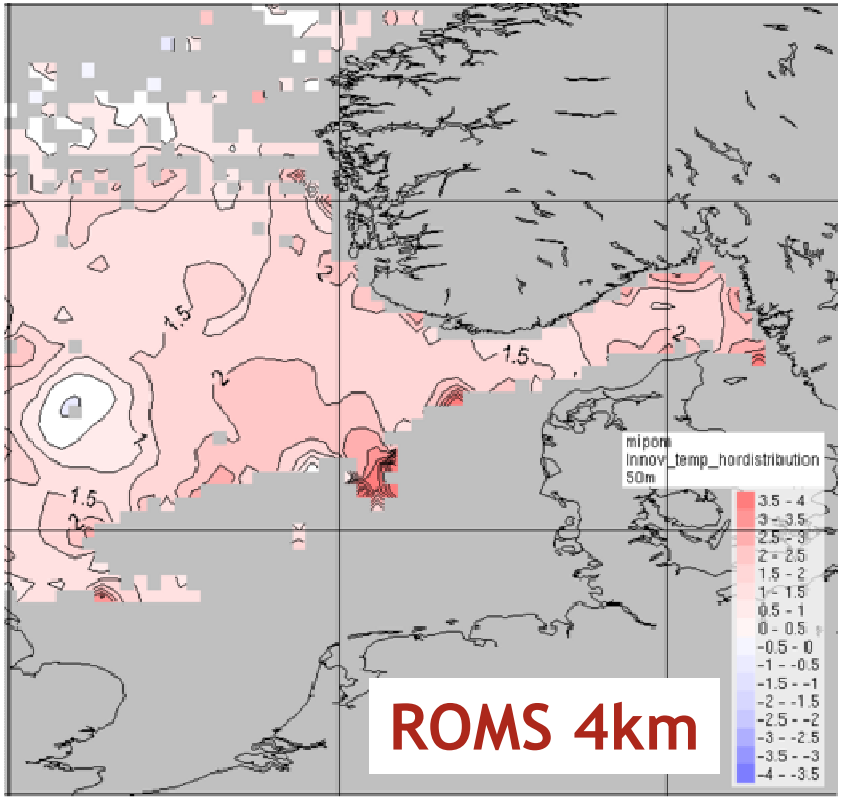




Temperature bias (mod - ICES obs)

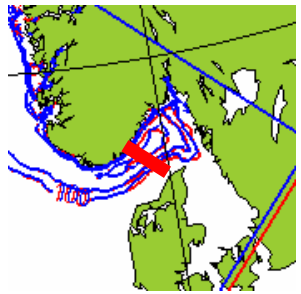
1981-2007 average; 50-600 m

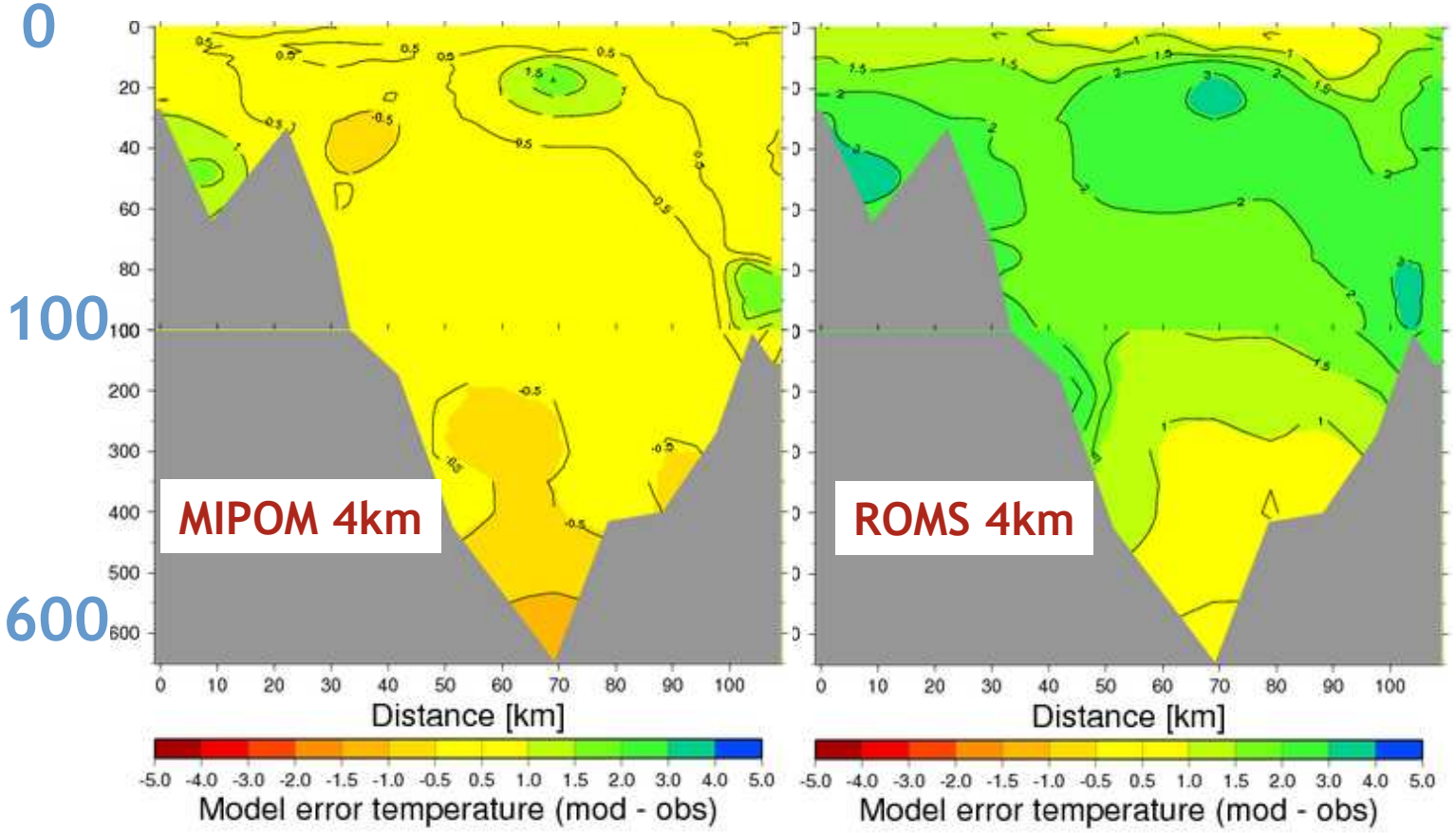




Temperature bias (mod – IMR obs)

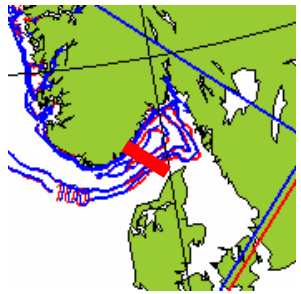
1981-2007 average

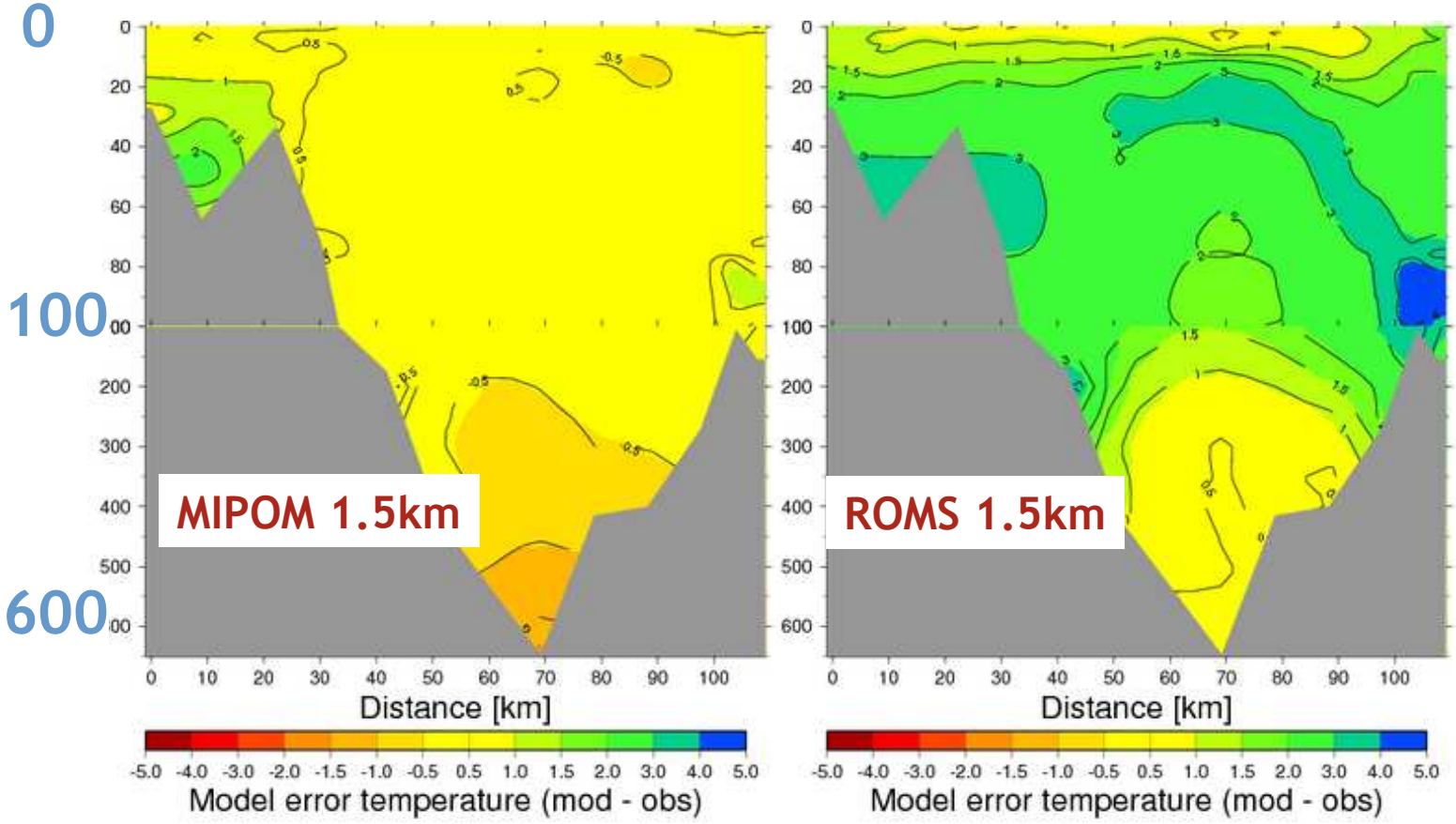




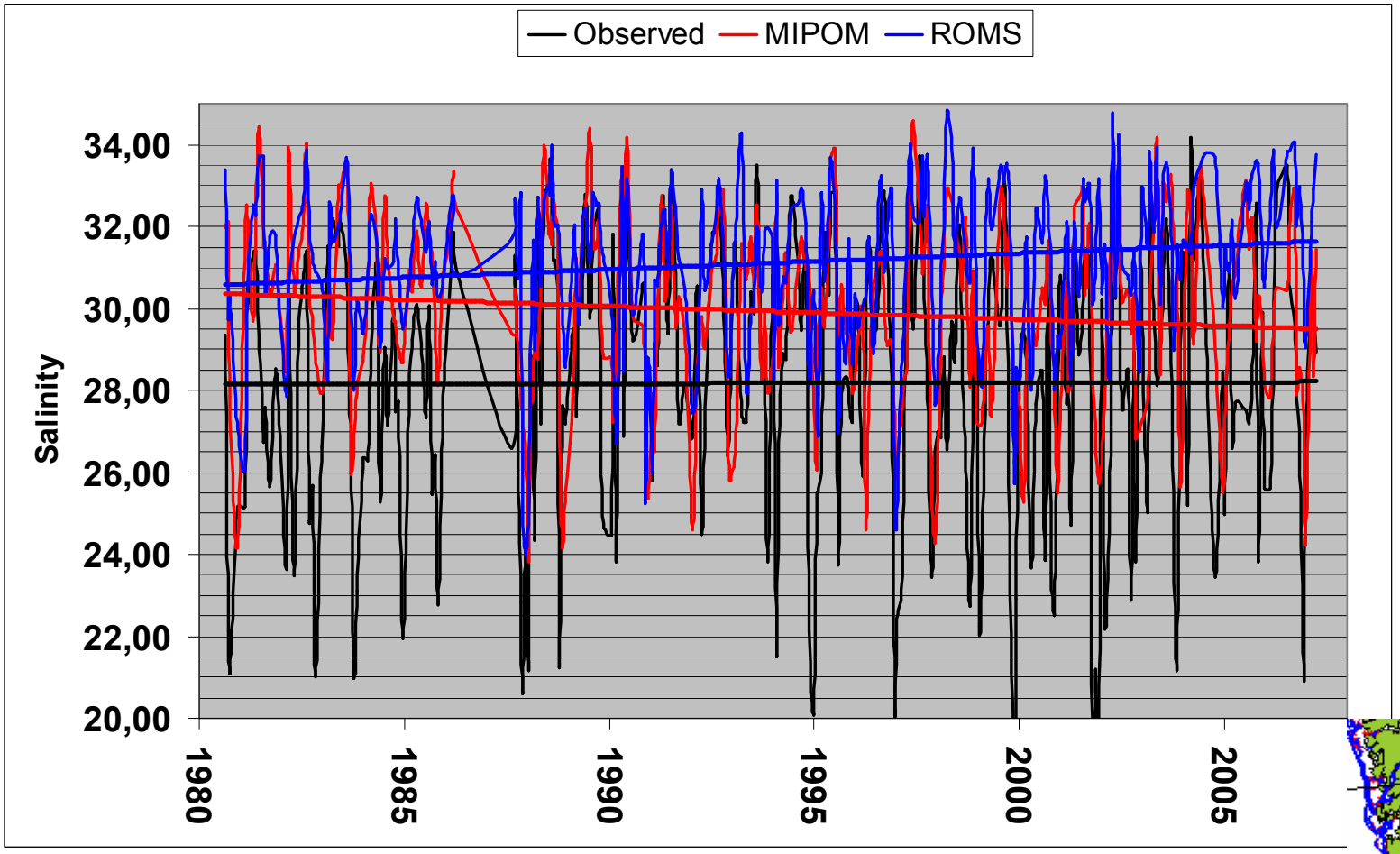
Temperature bias (mod – IMR obs)

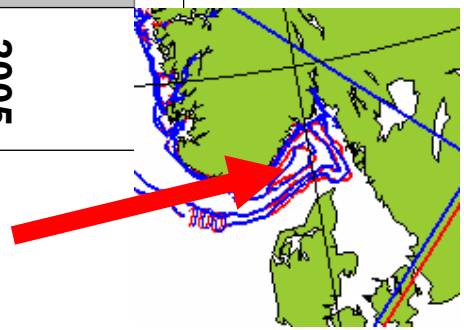
1981-2007 average



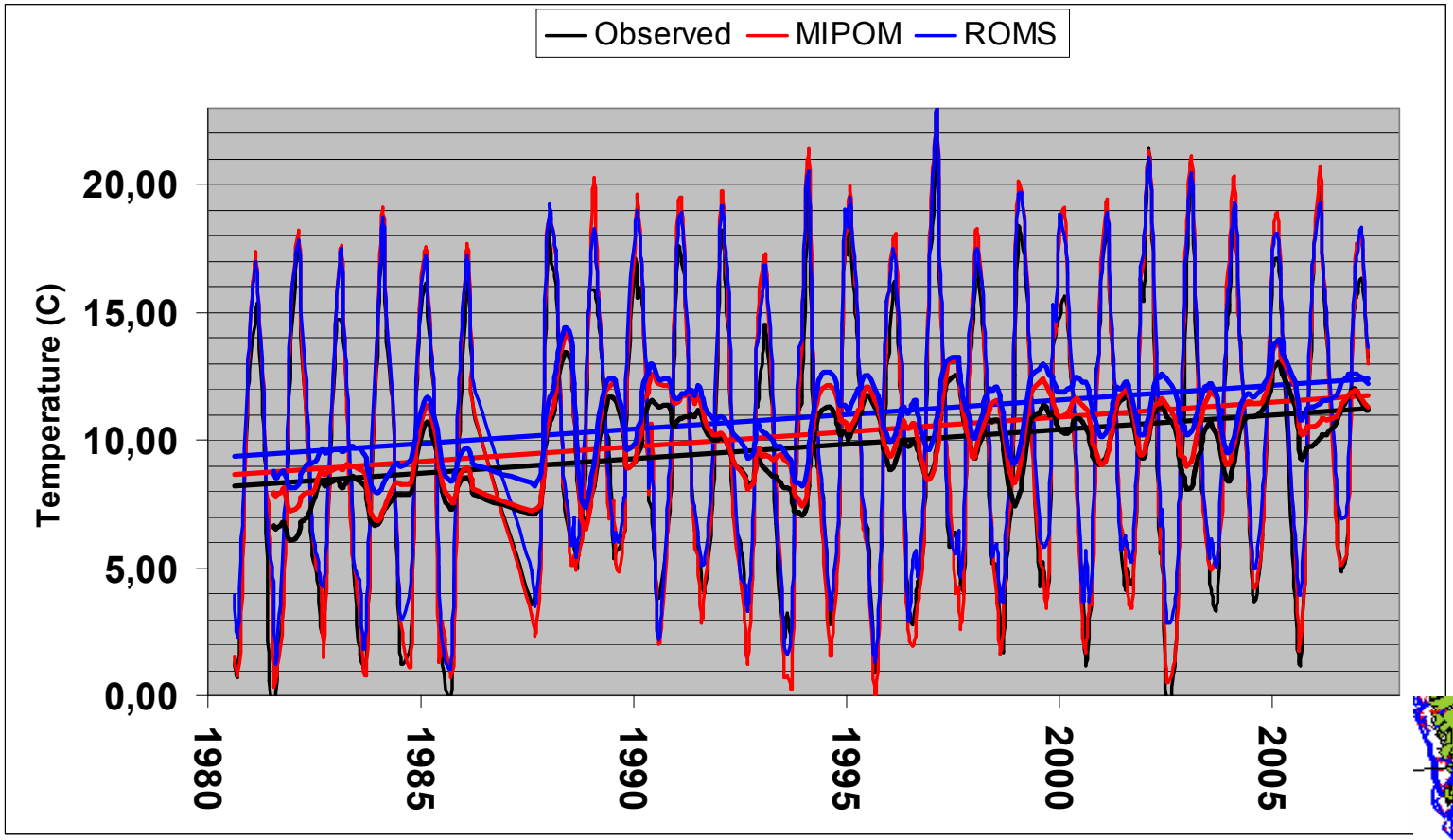


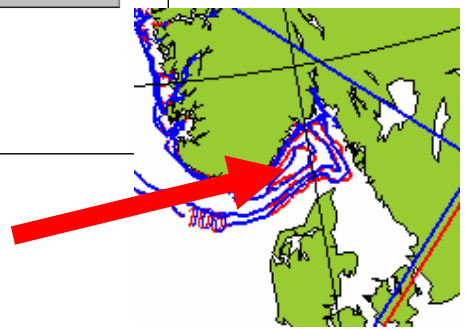
SSS off southern Norway



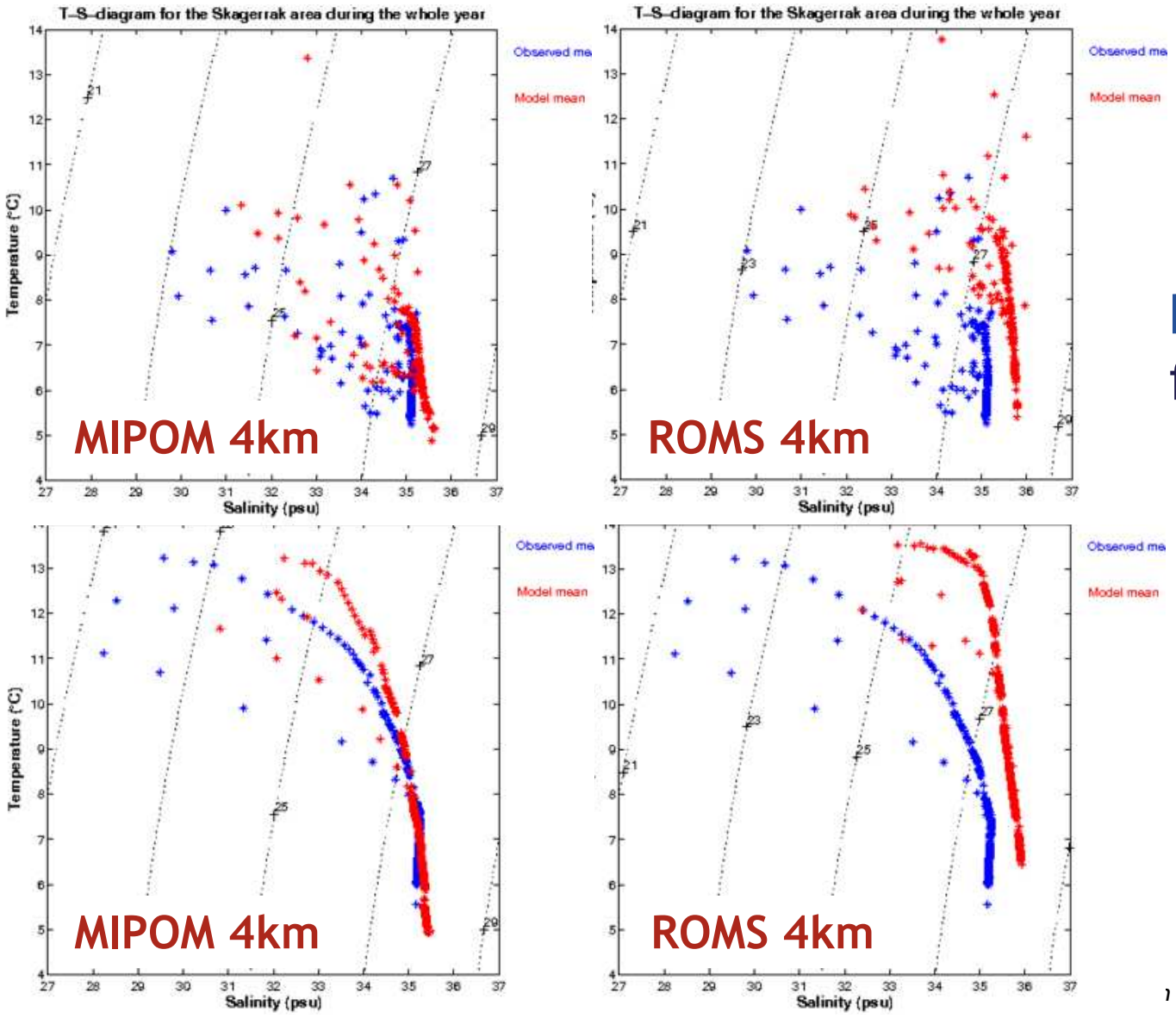


SST off southern Norway





T-S-diagram



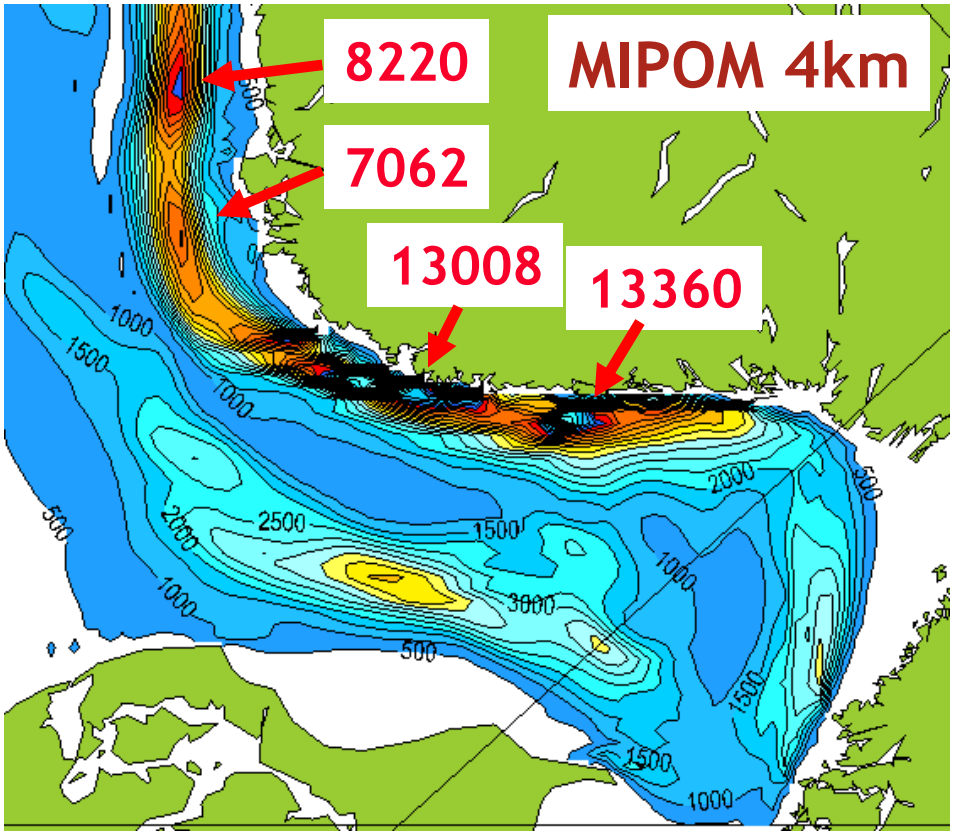
1983 average

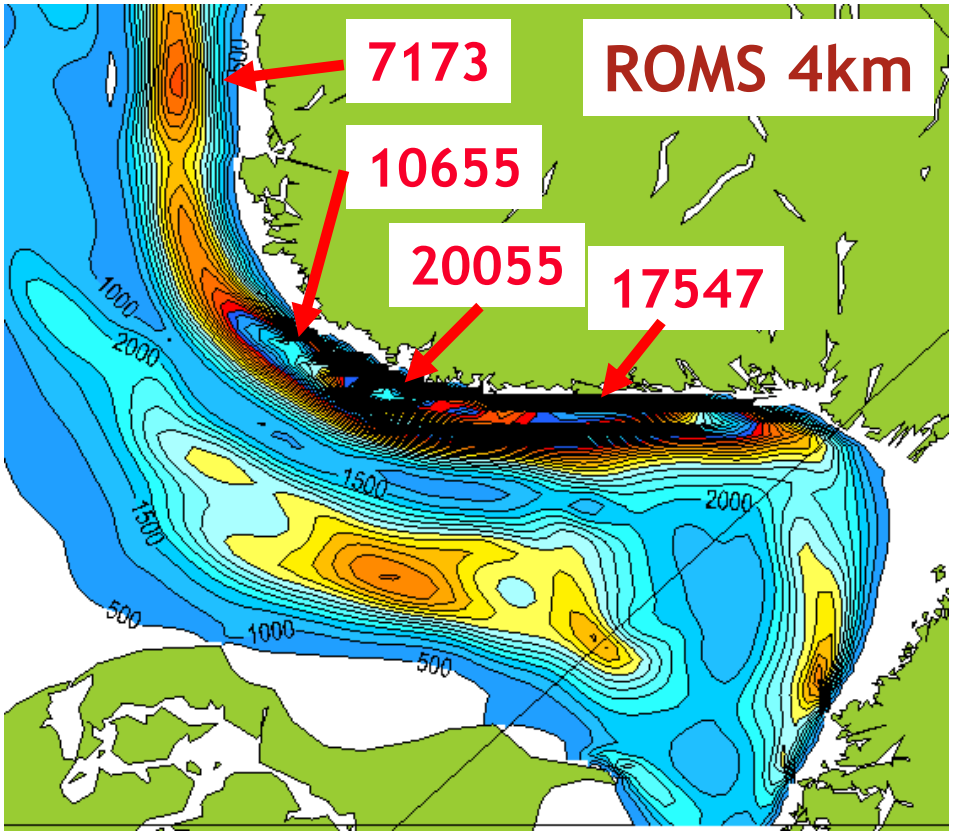
Blue: ICES data from Skagerrak

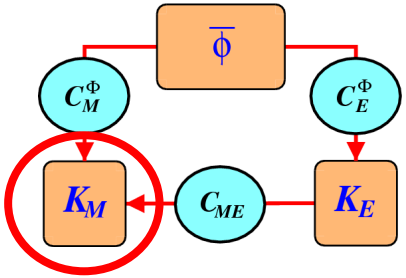
Red: Model

2005 average

Mean kinetic energy

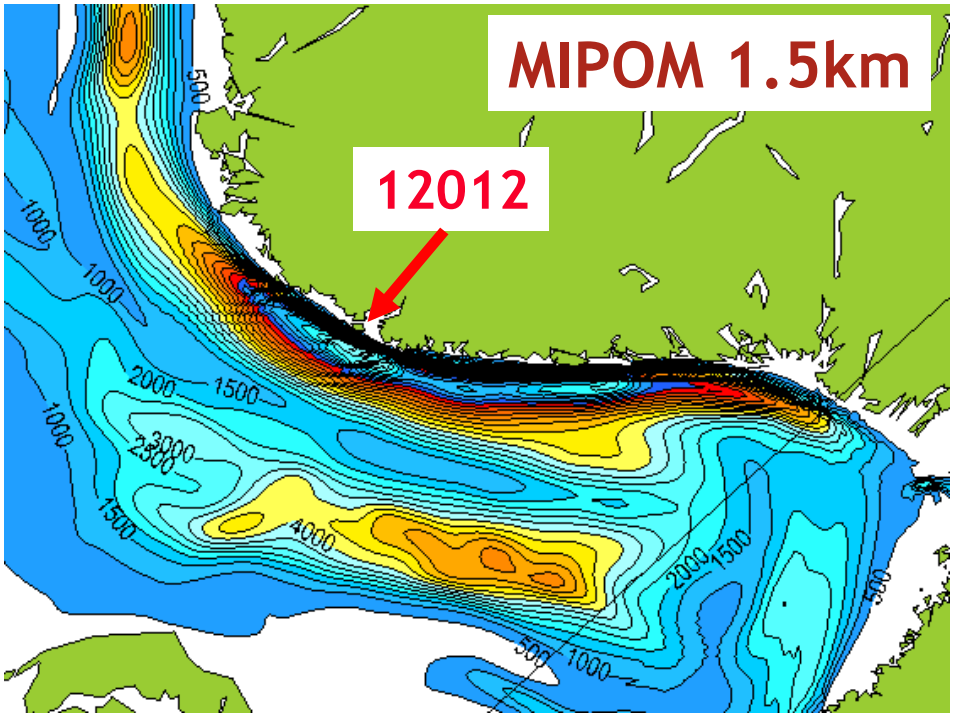


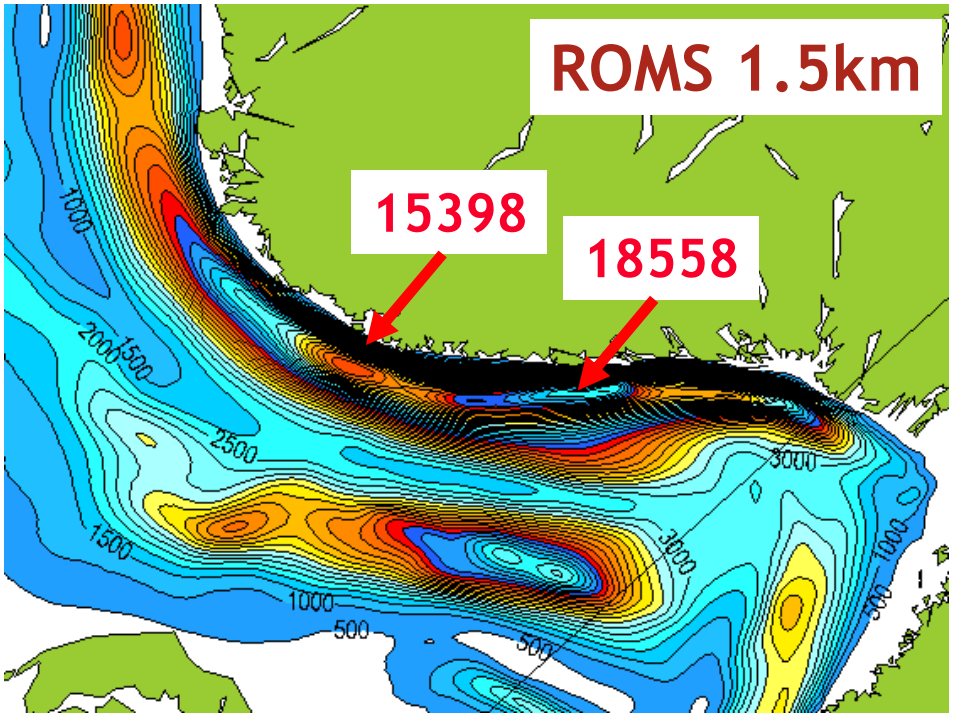


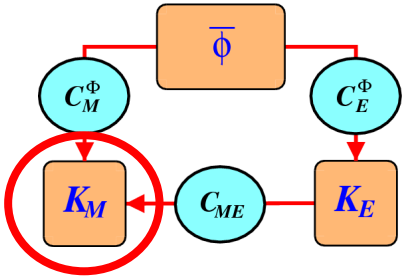


1981-2007 average (J/m2)

Mean kinetic energy

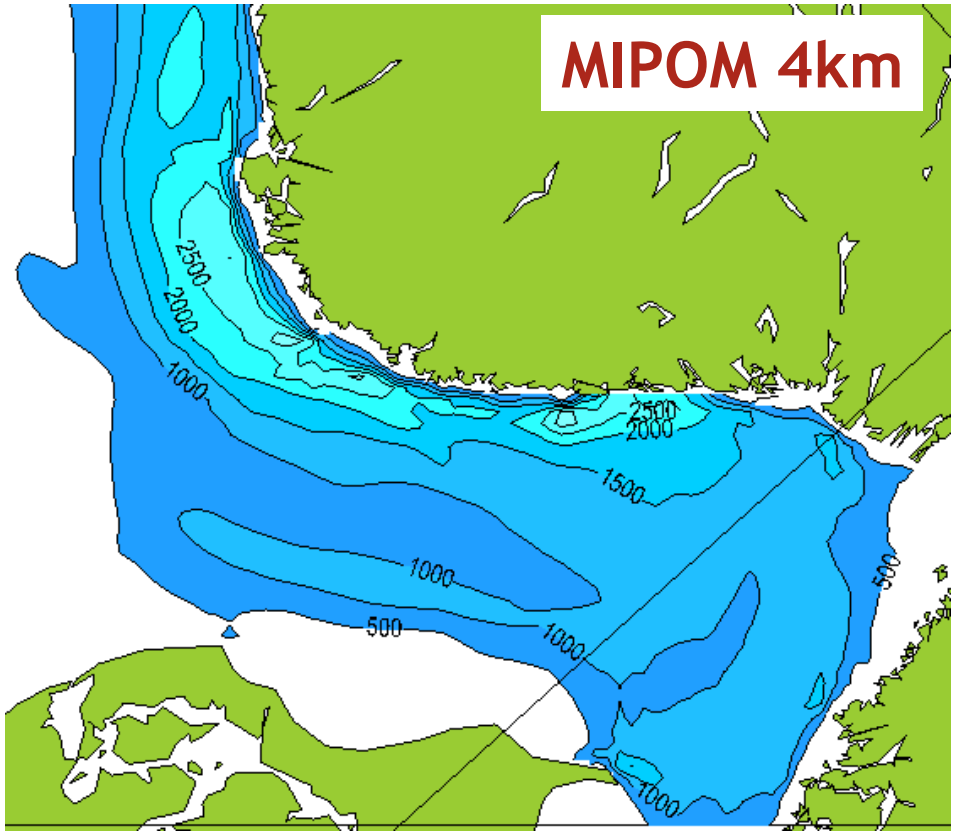


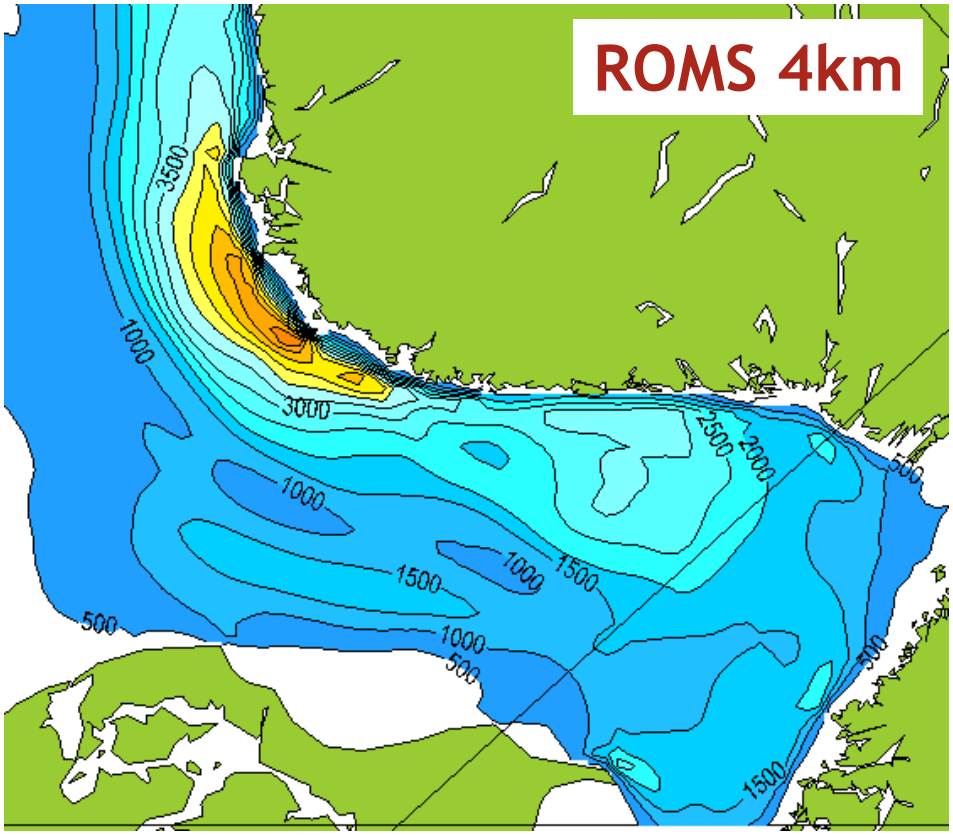


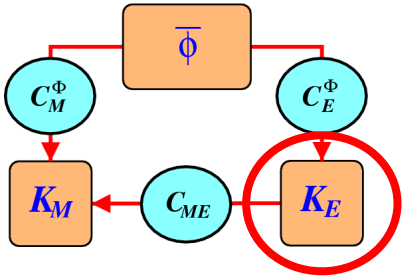


1981-2007 average (J/m2)

Eddy kinetic energy

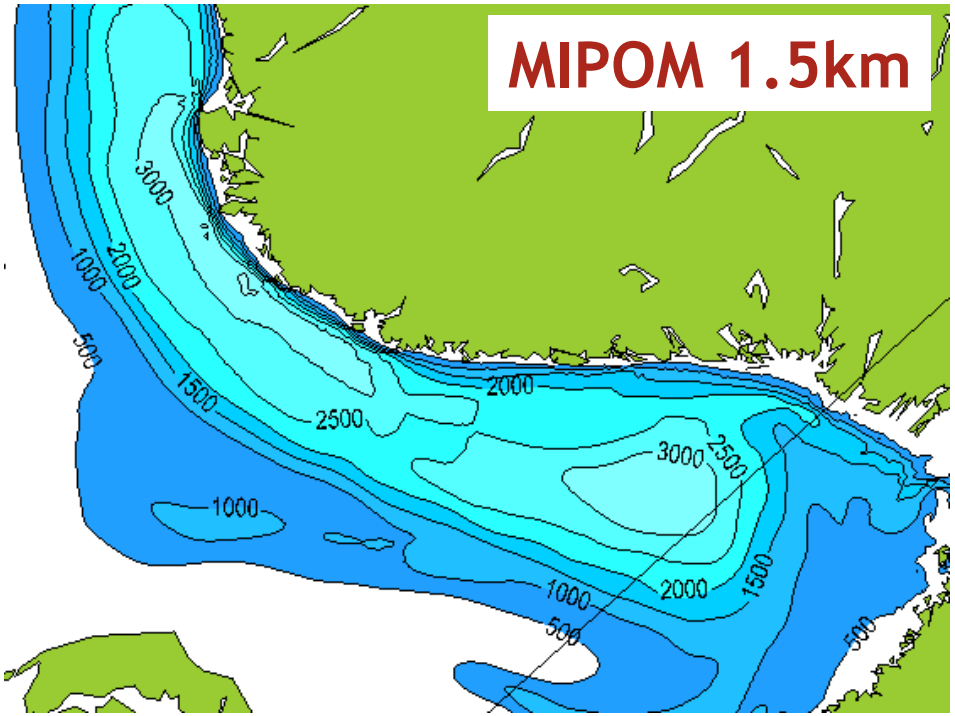


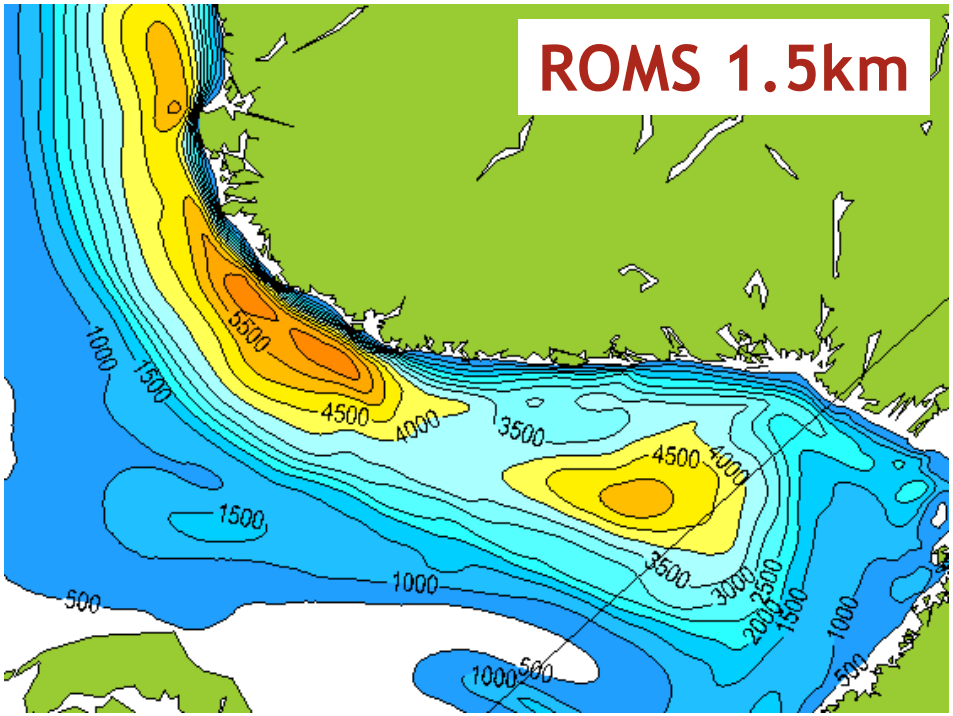


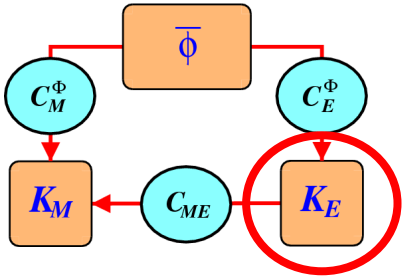


1981-2007 average (J/m2)

Eddy kinetic energy







1981-2007 average (J/m2)

Conclusions:

- Current structure north of Tampen confirms the *CONMAN* results
- MIPOM 1.5 km “best”
  - Constitutes a huge improvement in Skagerrak, in particular currents
- ROMS needs improvements:
  - Major biases in heat and salinity in Skagerrak

Conclusions MIPOM:

- Remarkable improvement in currents when increasing the resolution. Topography related ?
  - Model depth 233 ->163 m; real depth is 120m
- Scores well regarding currents along the Norwegian coast in Skagerrak:
  - Particularly the 1.5km model below the mixed layer
- Reproduces temperatures well (a small warm bias in the mixed layer)
- Decreasing salinity trend (-0,35 psu/decade)
- Positive salinity bias in the mixed layer

Conclusions ROMS:

- Surface currents validates well, but too speedy at depths
  - Slightly too energetic in the NCC below the mixed layer
- More energetic than MIPOM, particularly EKE
- Increasing salinity trend (+0,35 psu/decade)
- Too warm at all depths
  - A 1ºC warm-bias in SST in Skagerrak
- Too salty in the mixed layer
  - Slightly saltier than MIPOM
- 30% more water, 30% more salt and 50% more heat is advected in/out of Skagerrak
- Missing West Jutland current?
  - Very weak compared to MIPOM.


Thank you